IRON AND STEEL ENGINEER

J. F. KELLY, Editor

CONTENTS

Volume II March, 1925 Number III

Meetings and Papers II
Editorials III
Inspection Trip IV
Fuel Savings Conference V
Electric Arc Welding in the Steel Industry—By W. L. Warner..... 115
Thermit Welding—By H. D. Kelly 119
Cutting Steel Mill Maintenance Costs with the Welding Arc..... 122
By A. M. Candy.
Pipe Line Arc Welding—By R. R. Applegate..... 125
Production of Oxygen From the Air—By Don B. McCloud..... 127
Discussion: Electrically Heated Soaking Pits 129
Essentials of Design of Electric Industrial Furnaces and Their Application to Leveling Up Load Curves—By George P. Mills..... 136
Discussion: Gear Drives in Steel Mills—By W. E. Sykes..... 146

(List of Advertisers—Page VI)

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MEETINGS AND PAPERS

PHILADELPHIA SECTION

P. T. Vanderwaart, Chairman — L. O. Morrow, Secretary

Saturday, April 4th, 1925

General ideas and discussions. Every active member is invited to prepare a short paper on a subject pertaining to the application of electricity to the Iron and Steel Industry.

Engineers Club — Philadelphia, Pa.

CHICAGO SECTION

R. L. McIntosh, Chairman — W. H. Williams, Secretary

Wednesday, April 8th, 1925

Interesting and special applications of auxiliary motors and control in Steel Mills, by P. J. McShane, Engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

CLEVELAND SECTION

R. E. Scovel, Chairman — A. R. Lintern, Secretary

Saturday, April 11th, 1925

"Electric Power Generation by Blast Furnace Plant," by O. C. Callow, Chief Elec. Trumbull-Cliffs Furnace Company, Warren, Ohio.

PITTSBURGH SECTION

R. E. Lewis, Chairman — John F. Kelly, Secretary

Wednesday, April 8th, 1925

Inspection trip, Youngstown Sheet and Tube Company, Youngstown, Ohio.
Train leaves Pittsburgh 12:45 P. M.
Guests leave the Ohio Hotel 3 P. M.

Saturday, April 18th, 1925

"The Automatic Blast Furnace," by Frank W. Cramer, Bethlehem Steel Company, Johnstown, Penna.

EDITORIALS

ORGANIZING WELDING IN THE STEEL PLANT

By WALTER PETRY*

ORGANIZATION in industry has been the leading factor in bringing about the high standard of efficiency to which industries of this country have attained. Yet in many factories, shops, and mills, especially steel mills, we find today lack of organization in one of the most vital and growing methods of cost reduction, we have at our command.

Autogenous welding, when properly supervised, is a short cut and money saving engineering trade, without which industries in the future will be greatly handicapped. Mechanical and electrical problems have all been more or less standardized and worked out to a science for the last number of years, but welding is growing and increasing in importantce, needing, therefore, all the more careful study and protection. Protection from the misapplications which finally result in failure and a black eye for welding.

The definition of autogenous welding is in brief: The uniting of two or more metal parts to make one homogenous mass. The definition of autogenous welding can well be applied to organization of welding, in this way, that the different organizations for uniting metals be combined under one head making the organization one unit co-operating perfectly in its different branches.

The different branches of welding each have their own field of application to maintenance and production. These fields overlap considerably in respect to possibility, but in respect to cost, speed, and reliability there is a definite boundary line for each. For instance, a familiar example, a worn out sheet mill steel spindle, can be gas welded, thermit welded, or electric welded, but in the case of gas welding the cost would be double that of electric, and the thermit process would be more than double that of gas welding. This assumes that the work was properly engineered and highest grade materials were used, in each case making the finished spindle as good after one process as the other.

Many examples could be cited to illustrate the field boundaries, but it is sufficient to say that without the knowledge of the cost, speed, and reliability of doing them by each method, the engineer would be at a loss to pick the proper method.

Another great advantage of having the different branches of welding combined is easily seen in repair work, such as the following: A large steel housing, after being in service for several years is broken, and the fracture is of such dimensions that thermit welding is the only way it can be repaired. First, it is necessary to use the gas cutting torch to cut the clearance in preparation for the thermit weld, then the process of thermit welding during which time the worn down places can be built up by the electric arc, thus saving

*Welding Supervisor, American Rolling Mills, Middletown, Ohio.

(Continued on Page 148)

FACTORS INVOLVED IN THE SELECTION OF DIRECT-CONNECTED AND GEARED MAIN ROLL DRIVES*

By E. A. HURME†

The subject of Direct-Connected and Geared Main Roll Drives is not new, as the files of several engineering journals contain a number of articles dealing with different phases of this subject. It is the object of this paper to set forth, collectively, the main fundamental factors which should be given consideration in studying the subject of steel mill main roll drives, and to state briefly the significance of each of these factors.

The information given in the paper has been obtained through the close co-operation of many of the electrical, mill machinery, gear and coupling manufacturers. Also, many operating men have generously assisted with application and test data.

The information thus obtained has been carefully analyzed, and the results of the analysis submitted to the various manufacturers for their comments and suggestion. It will, therefore, be appreciated that the information given in this paper represents the accumulated experience and best judgment of a large number of engineers and manufacturers directly interested in this subject.

The question of the advantage or disadvantage of one method of drive, as compared with the other, is a broad one. The several factors involved, such as first cost, performance, space occupied, flywheel effect, maintenance, etc., vary in their relative importance in different plants, and at times an extensive analysis is required before the final choice is made.

Major points to be considered in the paper are:

1. Object of paper.
2. Development of Main Roll Drives.

   Industry has gradually changed from the early direct-connected motors to the present-day more extensive use of geared units. At present only 30% of the new installations are direct-connected, while 69% are geared.
3. Frequency.

   Twenty years ago 25-cycle power predominated in the steel mill industry. There were good reasons for that. Today 23% of all new installations are 25-cycle and fully 75% are 60-cycle.
4. Power Factor.

   On early installations little, if any, attention was given to the power factor. Today, it is attracting considerable attention. Causes of low-power factor are described and the interrelation of speed and power factor illustrated.

*To be presented before Pittsburgh Section, March 21, 1925.

†Manager, Steel Mill Section, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

(Continued on Page 150

INSPECTION TRIP

TO

YOUNGSTOWN SHEET & TUBE CO.

YOUNGSTOWN, OHIO.

ONE OF THE MOST

MODERN SHEET MILL PLANTS

WEDNESDAY, APRIL 8th, 1925

Train leaves Pittsburgh 12:45—P. & L. E., S. S., Pittsburgh, Pa.

Train arrives Youngstown 2:20 P. M.

Headquarters Ohio Hotel.

Inspection party will leave Ohio Hotel at 3 P. M. for Steel plant.

Complete details and announcements will be mailed to you.

The equipment of the following firms was used in the construction of this sheet mill:

Blowers: Connersville Blower Company.
Motors—Starters: Westinghouse Electric & Mfg. Company.
Constello Furnaces: Tate Jones & Company.
Dryers—Oilers—Stretcher Levelers: Aetna Fdry. & Machine Co.
Main Roll Train—Cold Roll Train—Charging Machines: United Engineering & Foundry Company.
Main Gear Drive—Picklers: Mesta Machine Company.
Couplings: Thomas Flexible Coupling Company.
Cold Mill Drive: Falk Corporation.
Cranes: Morgan Engineering Company.
Building: Truscon Steel Company.
Shears: Hyde Park Foundry & Machine Company.
Scrap Press: Logemann Brothers Company.
Outdoor Sub-station: Industrial Railway & Engineering Co.
Roller Levellers: McKay Machine Company.
Tractors: Elwell Parker Company.
Roll Heaters: Freyn Engineering Company.
Transformers: Pittsburgh Transformer Company.
Fibre Conduit: Johns Manville, Inc.
Pyrometers: Bristol Recording Clock Company.
Hydraulic Pumps: Wilson-Maulen Company.

*Electric Arc Welding in the Steel Industry**

By W. L. WARNER†

THE art of welding is old, but electric arc welding as a science, is a comparatively recent development within the past two decades. Heat is generated by an arc which is formed by a gap in an electric circuit. The heat of the arc causes fusion to occur between the parts to be welded and metal is generally added from an external source to complete the weld. Certain kinds of metal can be deposited with the electric arc under suitable conditions. Sheet steel a sixteenth of an inch thick or a break in a large casting may be welded with the electric arc. In either case the capability and experience of the operator affect to a great extent the quality of the finished job.

In the steel mill the opportunities for utilizing the electric arc in repair work and for salvaging worn parts are very numerous. They are more numerous, in fact, than we realize. The product is steel and steel machinery is the necessary equipment for this manufacturing process. Breaks will occur under the severe service required, and certain parts are very quickly worn sufficiently to require replacement or repair. In most cases, it is of prime importance to avoid delay or inactivity, as idleness costs real money in a steel mill. The shut-down of one part of a mill means a cessation of activities of the whole mill.

However, it must not be supposed that all machinery parts are allowed to wear out before replacement. In fact, whenever excessive wear on any part is noticed, a new part or one previously repaired by welding may be inserted, thus avoiding undue stresses in various parts of the machinery caused by a sudden failure of one part. Practices vary, however, in different respects in the various steel mills throughout the country.

In the brief discussion given above, the writer does not mean to imply that failures of parts of a steel mill are necessarily repaired on the spot by electric arc weldings, or that the savings effected by the electric arc are primarily achieved in this way. In fact, many repairs which are made by electric welding require a longer time than would be required to put a new part in the place of the one which is broken or worn out. But, if new parts were inserted for broken ones every time failure occurred, the cost would be enormous. However, broken parts can be salvaged with the electric arc in the welding shop and be put back in service again with a cost much less than the cost of a new part.

Even if it were possible to carry a sufficient stock of new repair parts to keep the mill in continuous production, the cost of replacement would be staggering. The electric arc welding process will cut maintenance cost tremendously and in varying degrees, depending on the class of work done.

Spindles

The most universal repair which is at present done with the electric arc is the building up of worn wobblers on mill pinions and spindles. In some welding shops the deposited metal is hammered as each layer is added thus eliminating some of the internal stresses. Sometimes, the outside layer is put on of manganese steel, so that a manganese content of probably from 10 to 12 per cent is obtained. When welded in this way the length of service obtained from the repaired wobbler is often greater than the original new part could give. This difference, of course, varies, depending on whether the spindle or pinion is of forged or cast steel. New wobblers will last about three months in service, while welded wobblers often last over six months. This saving effected by welding over replacement by new parts may be considered in a different light when it is known that the repair of worn wobblers by welding costs between $30 and $100, while the cost of a new spindle or pinion is from $1,000 to $2,500. As an illustration, an actual case may be cited in which a spindle 22½ feet long and 16 inches in diameter at the center was repaired by arc welding. The jaws of the wobblers were 8 inches deep, 8 inches wide, and 12 inches long and were worn on each side, because the spindle had been reversed while in service. In this case, therefore, 16 jaw sides were built up and approximately 85 lbs. of electrode material was used. The total cost was about $51, while the cost of a new spindle would be about $2,000.

Let us consider the table rollers. There is a considerable saving effected not only in the manufacture, but also in the maintenance of the cast steel roll. Blowholes occur in the roll surface or defects exist in the bearing surface.

Either the metallic arc or the carbon arc are used for filling up these blowholes. While in service, the roll pinions sometimes crack, some teeth break out, or the pinion breaks loose from the roll entirely. These types of failures are easily and cheaply repaired by electric arc welding. In some cases table roller bearings when built up by arc welding have lasted about six months longer than new ones.

Sheet Mill

One instance of the savings effected by electric welding may be cited in the hot sheet mill where several cast steel roll housings had broken and were successfully welded with the electric arc. These housings weigh from 15 to 16 tons and cost about $3,000 when new. The average cost of repairing the fractures was about $500 each and in one case it was stated that 12 of these housings in one mill are welded and in service at the present time. These housings have now been in service on an average of about 2½ years. In this case alone, the use of arc welding effected a clear saving of approximately $30,000. This amount certainly more than paid for the first cost of the welding apparatus required to do the work.

In the hot sheet mill, the roll train rider ears slide in guides which confine the rider to an up and down motion. The ears wear thin after a length of time and must be thrown away, unless the original thickness can be restored. This has been successfully done with the electric arc. On the average a pad of metal ½ inch thick must be deposited on each ear. The ears are about 8 inches long and 3 inches wide. Between 3 and 4 of these riders can be welded in 10 hours,

*Presented at Pittsburgh, December 13, 1924.

†Engr., Industrial Dept., General Electric Co., Schenectady, N. Y.

using between 11 and 13 lbs. of electrode material. If the deposited metal is built up exactly to size and hammered thoroughly, no machine work is necessary, as a hard, smooth finish may be obtained without machining. If machining is resorted to usually about 6 riders may be completely machined in two hours. The average total cost of making the repairs necessary is about $3.25 per rider. This figure will vary, depending on the amount of wear and the size of the rider ears. This is a great saving.

In the hot steel mill also there are annealing furnaces used for bringing the sheets up to the proper temperature for rolling. The sheets are passed slowly through the furnace on water-cooled disc rollers, which are slowly turned by machinery external to the furnace so that the sheets of steel are thoroughly soaked with heat. It has been found that the disc rolls frequently burn through because of air pockets which have formed inside of the disc, due to their rectangular cross-section. In order to avoid this condition, one welder devised a new type of roll made of standard pipe made up in a spiral form with the connections welded. The rolls cost about $25 each complete. Several furnaces have been equipped in this way and are in satisfactory operation without any failures to report, although this operation has not been of sufficient length to prove conclusively that the new rolls are an improvement over the old ones. These new rolls are a distinct departure from the former type of disc rolls and it is believed that due to the nature of the construction, these rolls will long outlast the previous type of disc rolls.

Another piece of machinery which sometimes breaks is the plate shear in the sheet mill. The writer has seen a large shear on which one end of the head was cracked for about 14 inches. This crack was welded with the electric arc. The shear is now in continuous operation with no further signs of failure.

In the strip mill we find the electric arc used for building up the bearings or repairing cracks in table rollers. These welded rollers are stated to give over 6 months' longer service than new rollers. In some cases, the strip mill guides, whether of rolled, forged or cast steel are welded throughout.

Blooming Mill

Some parts of the machinery customarily found in the blooming mill, bar mill or structural mill are economically repaired with the use of electric arc welding. Certain parts, such as wobblers, and table rolls, have been mentioned. The gear pinions for the manipulators or the strip mill pushers are easily and economically repaired and put back into service. In one instance, a 15-toothed gear has had 8 teeth built in by arc welding and is in service at the present time. The screw-down for the blooming mill sometimes needs a thread built up or some of the teeth in the gears have broken out. Repairs of this nature are easily and quickly made with the electric arc and the repaired part is ready for further service instead of the scrap pile.

Sometimes a main roll bearing cracks or the lugs are broken off. Instead of scrapping the bearing, repairs can easily be made with the electric arc and the bearings may be put back in service. In one instance a bearing lug was welded to the bearing and a crack in the bearing repaired, at a cost of about $9. It was stated that a new bearing costs between $350 and $400. Cracked bearing housings and spindle couplings may also be returned to service in a similar manner.

The modern trend toward electrically driven rolling mills and accessories has necessitated a large number of small motors for operating steel mill accessories. In most cases, these motors are situated in the mill adjacent to the apparatus operated by them and are subject to very severe service. Usually, there is no careful inspection of these motors maintained, except to take up the bearings sometimes when the motor

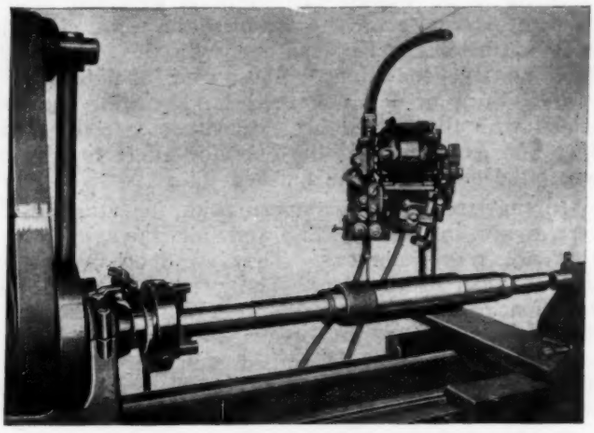

FIG. 1

vibrates excessively. The mill operates until a motor fails, either due to a worn commutator, worn shaft, or a burned out armature or other causes. Perhaps the bearings need rebabbitting or the shaft is worn so that the bearings cannot be tightened any more. At any rate, the motor is replaced by a spare and the mill goes on rolling steel. But what happens to the motor which has just been replaced? It is sent to the electrical repair shop.

In the repair shop the motor is dismantled and if the armature is burned out or the field coils injured, new windings are put in. Sometimes only the shaft is worn and a new one is inserted or the old one is repaired by depositing metal on the worn spot with the electric arc. The rebuilding of worn shafts by the

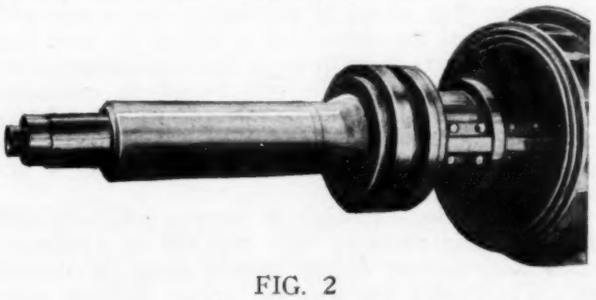

FIG. 2

automatic arc welding process is a simple everyday proposition, as shown by Figs. 1 and 2.

In Fig. 2 is shown the armature shaft of a 2,500 KW generator which has been built up in this way and machined to size. The weight of this armature is 12,000 lbs. The welding and machining was done without removing the shaft from the armature. This application of arc welding represented a considerable yearly saving not only by salvaging the worn shafts, but also by speeding up the repair work which elimi-

nates the necessity of tieing up a large amount of money in extra spare parts.

In the case of the steam driven rolling mill, the crank shaft of the motor might break, as shown in Fig. 3. Fig. 4 shows the broken crank shaft completely repaired with the electric arc process. While a break of this character is probably a rare occurrence, nevertheless the use of the electric arc welding will

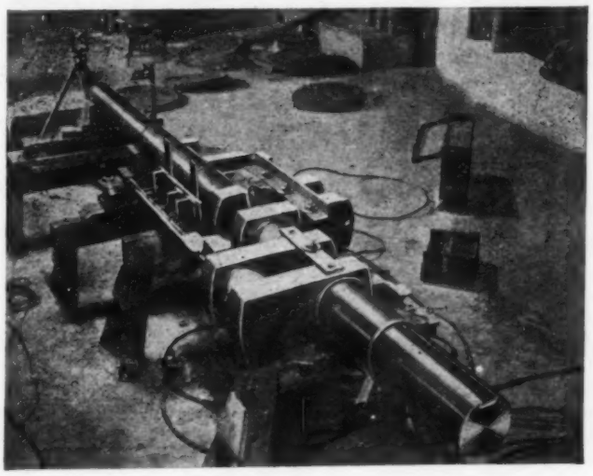

FIG. 3

save considerable time and money should the need arise. The many details which must necessarily be considered are partially illustrated in Fig. 3. This shaft must necessarily be very carefully lined up prior to welding and it is absolutely essential that this accurate alignment be maintained during the welding and until the weld has cooled.

Foundry and Furnaces

In the open hearth furnaces, foundry, and blast furnaces, arc welding is of valuable assistance. Water

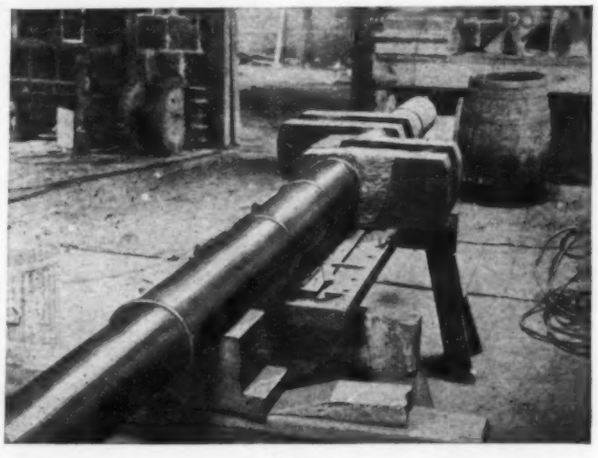

FIG. 4

coolers for the open hearth furnaces are constructed in some cases by simply welding a strip of sheet steel of the proper width across the front of a structural channel, thus forming a water tight chamber of approximately a rectangular cross-section. Small pieces of sheet steel are welded to the ends closing the openings. Pipe connections are welded into the ends so that water can be circulated through the chamber. This method of construction lends itself readily to any size of water cooler which may be required.

It sometimes happens that the peel of the charging carriage breaks. A new peel may be inserted and the broken one repaired in the welding shop. Breaks in the gears or travel mechanism of the charging carriage may be also repaired by welding. Sometimes the doors of the open-hearth furnaces develop cracks which are easily and quickly repaired with the electric arc.

For repairing defective castings in the foundry, the electric arc is of great assistance and many thousands of dollars are saved each year by its use for filling blowholes and building up undersized parts. The electric arc also offers many inducements for cutting up steel scrap for charging the cupola or removing risers from steel castings.

Transportation System

The maintenance of satisfactory transportation facilities between buildings and departments demands a certain amount of study. Most every steel plant maintains a more or less complete steam railroad system for moving materials from place to place. The locomotives require periodic inspection and repairs. New flues must be inserted or a new flue sheet put in. A crack in the firebox must be repaired. Perhaps there is a broken frame to be repaired. Electric welding will make the necessary repairs with the least expenditure of time and money. Worn motion parts may be easily built up to the proper size with the electric arc. New journals may be restored or the old ones repaired. The electric welding arc is indispensable in the locomotive shop. Frequently repairs can be made without the necessity of any dismantling, thus shortening the time of idleness of the locomotive.

Track maintenance and upkeep of yard cars also is of some importance in a steel mill. Switch points, cross-overs, and frogs are easily built up to proper size. A rod of about 12 or 13 per cent manganese content is sometimes used in order to obtain a wearing surface which will resist abrasion. After the welding is completed grinding is sometimes resorted to in order to smooth up the wearing surface. Rail bonds are quickly and easily attached by electric arc welding. Car couplings and journal boxes are sometimes repaired and put back in service without any appreciable cost. Worn journal boxes may be re-lined or worn spots reinforced by putting on a steel plate in some cases.

Pipe Lines

Often times leaks occur in water or steam lines which can be quickly and conveniently repaired by electric arc welding. Welded pipe lines can be installed more cheaply and easily than any other type of jointed pipe. In one case 400 ft. of 6-inch steel pipe for a water line carrying 400 lbs. pressure was successfully installed in a steel plant. The pipe lengths were 20 ft. and the thickness of wall was $\frac{3}{8}$ in. Each joint was beveled at 45 deg. and welded with the electric arc. The cost per joint was approximately $1.55.

In the foregoing discussion the writer has attempted to enumerate the various applications of electric arc welding which may be found in and around the average steel plant. There are probably some which certain ambitious welders have developed that are not mentioned here, but in the main the great use to which the electric arc welding process is being put every day in the steel mill shows that electric arc welding does

satisfy a universal demand. This process has been termed "The ironworker's needle and thread, a universal saver of time, labor, money, and materials."

In addition to the many applications of electric arc welding in the steel mill where steel is made, there are many interesting instances where the process may be

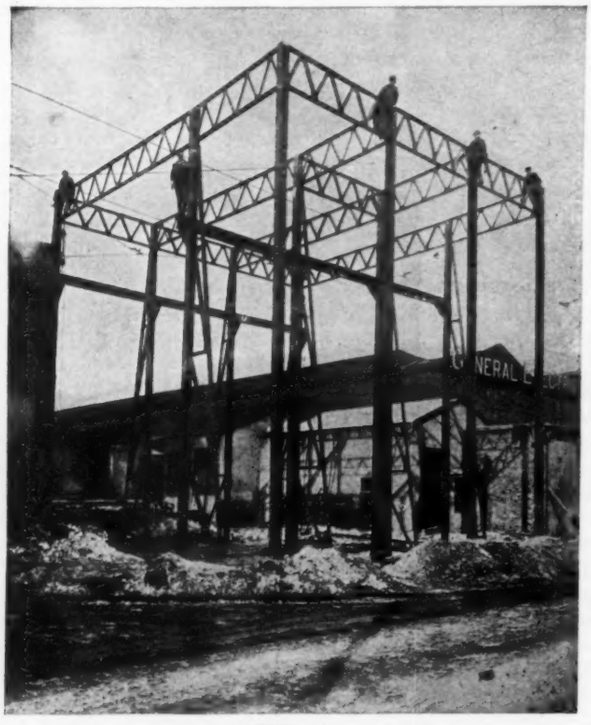

FIG. 5

advantageously used in the fabrication of steel products. A few examples are given below:

Fig. 5 shows a structural steel framework 40 ft. high and 40 ft. square erected using welding in place of rivets. The total weight of steel used in this framework was 39,334 lbs. The cost of erection was $105.75 and it was estimated by the builder that the cost of

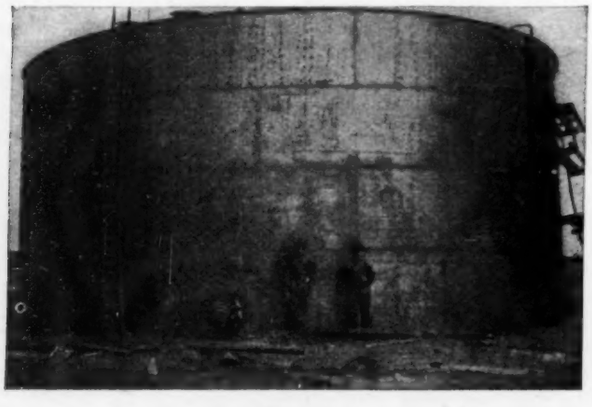

FIG. 6

erection using rivets would be about $197.75. These figures do not show the savings in labor and materials gained by eliminating punching of rivet holes.

Fig. 6 shows an oil tank 20 ft. high and 43 ft. in diameter. This tank was completely arc welded throughout and when completed was filled with kerosene to test for leaks. After 36 hours of test no leaks appeared.

Fig. 7 shows the arc welded pipe connections between the gas generators and a collector header at a municipal gas plant. The upright pipes are 20 inches in diameter and the header is 28 inches in diameter.

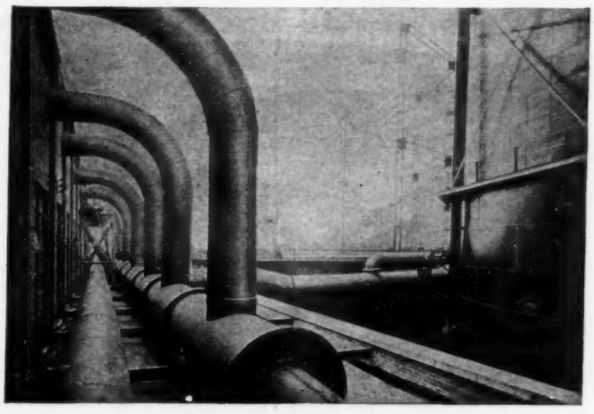

FIG. 7

A considerable amount of this type of construction is sometimes used in gas generating plants.

Fig. 8 illustrates an extensive application of electric arc welding to ship construction. This boat is an all-welded oil barge, the first ever built in America. The boat is 76 ft. long, 21 ft. wide and 11 ft. high with a tank capacity of 52,000 gallons. No rivets were used in this boat.

There are several reasons why the electric arc welding process should be considered for general repair work in the average steel plant.

First, the use of electric arc welding eliminates the necessity of tieing up large amounts of working capital in new spare parts.

Second, the use of electric arc welding decreases the cost of replacement to a very great extent. In many cases the worn out part can be rebuilt at a fraction of the cost of a new part and the amount of service obtained from the part so rebuilt will be equal to

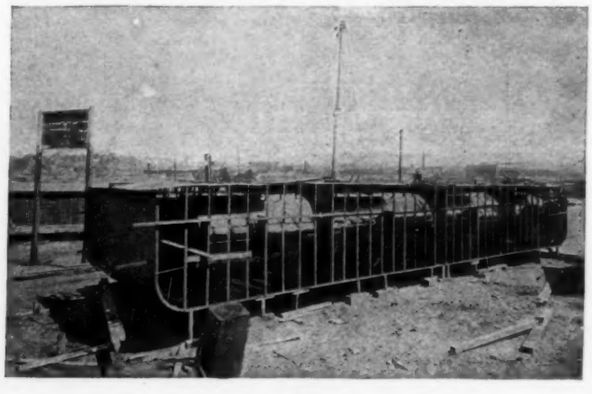

FIG. 8

and often greater than the amount of service obtainable from a new part.

Third, the use of electric arc welding eliminates considerable delay in making repairs or replacements.

Fourth, the electric arc welding process is successful when handled by an experienced welder operator.

In general the writer has endeavored to show the wide range of opportunities offered for using electric welding. While the possibilities of electric arc welding are now becoming recognized by the steel industry to a certain extent, yet there is still room for advance. The expansion of the process depends to some extent upon the supply of competent and experienced operators. Good, sound, strong welds are required because of the heavy service which must be experienced in a steel mill. Every failure means a loss of money and the executive in the steel industry is rather cautious. This caution must be replaced by confidence, not only in the welding process but also in the welder himself. Eventually this condition will be realized.

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*Thermit Welding**

By H. D. KELLY†

IN this topical discussion of Welding, the Thermit Process has been assigned to me, and you gentlemen, no doubt, are all familiar with the Thermit Process, as it has been used in steel mills for the past fourteen years with very successful results.

It is not my purpose to deal with this subject from a technical point of view, but I will endeavor to present to you some of the practical experiences that I have acquired in my dealings with the Steel Industry, explaining to you for what purposes Thermit has been most successfully used and also where it should be used, in order to show the savings in time and in money in recovering and salvaging many of the parts which formerly found their way into the scrap department.

Thermit is not adapted for welding light or sheet sections, but is principally used for heavy sections,

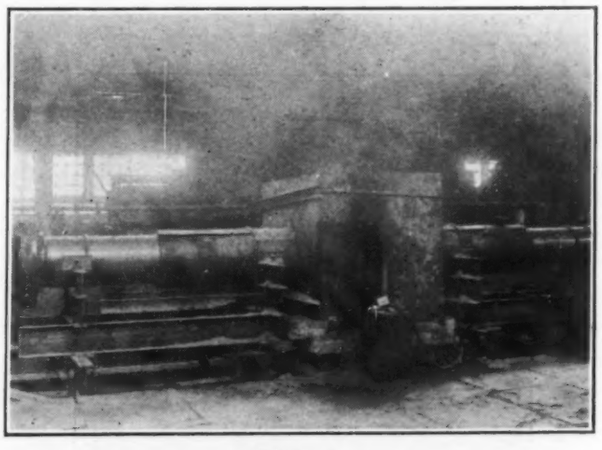

FIG. 1

and it has been proven that the use of thermit will show a savings anywhere from 50% to 90% of the original cost of the part being salvaged. Thousands of dollars are lost each year by allowing many of the broken parts to find their way to the scrap pile that could be easily recovered with the use of Thermit.

Thermit Welding is easily and quickly done. Not a man equation, but simple rules that must be followed, in order to get the best results. Thermit steel has great tensile strength and shock resistance. When a thermit collar has to be entirely removed the weld will be very close to 90%, and if clearances will permit the

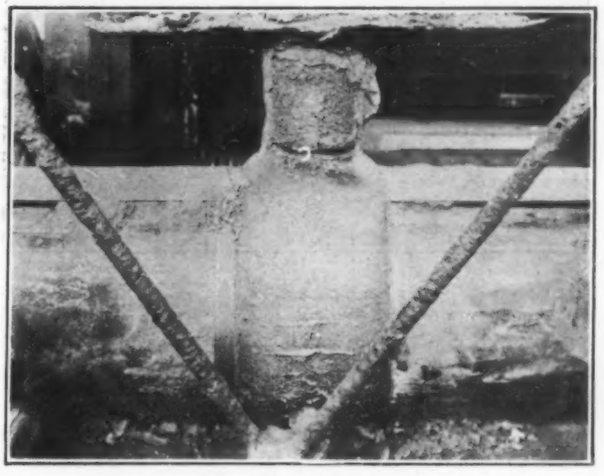

FIG. 2

collar to be left on very close to 100% of the original strength of castings may be obtained.

It is possible to thermit weld heavy sections of cast iron, however preparations must be made to take care of contraction.

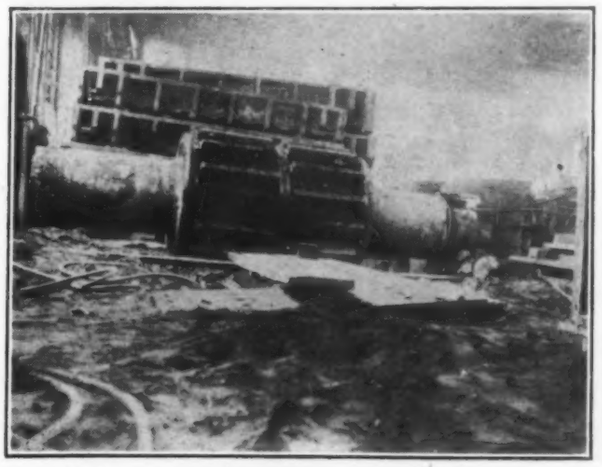

FIG. 3

*Presented at Pittsburgh December 18, 1924.

†Dist. Mgr., Thermit Dept. Metal and Thermit Corporation, Pittsburgh, Pa.

In the Iron and Steel Industry, where the Thermit Process is used, many successful thermit welds have been made and thousands of tons of steel forgings and castings have been recovered, thereby not only pre-

FIG. 4

serving the continuity of operation for the steel industry, but also showing a saving of hundreds of thousands of dollars.

The Thermit Process is used to recover crank shafts, straight shafts, press housings, shear housings, pinion housings, roll housings, broken necks on pinions and rolls, also it is used to build up worn pods on pinions and rolls, broken frames on shifting engines,

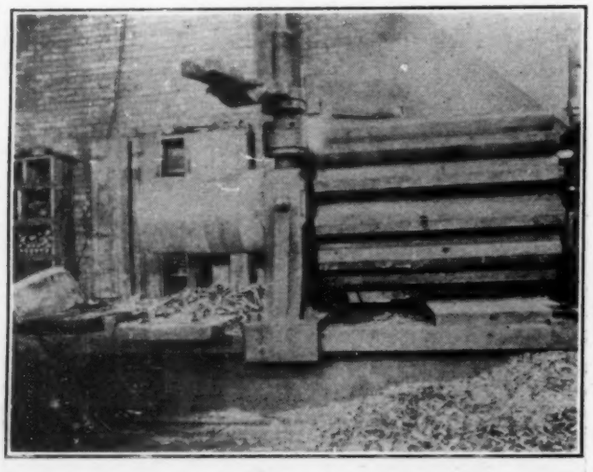

FIG. 5

welding rail joints, stakes for bull riveters, coupling boxes, mill spindles, cinder ladle cradles, truck axles, parts for hydraulic presses, and broken teeth in gears and pinions.

It has been found that with the addition of manganese a much more successful weld may be produced when building up the worn pods on pinions. They practically wear indefinitely.

It is our humble opinion that if the Iron and Steel Industry could see their way clear to organize welding departments, immense savings would immediately result. Also, it would not be necessary to carry the

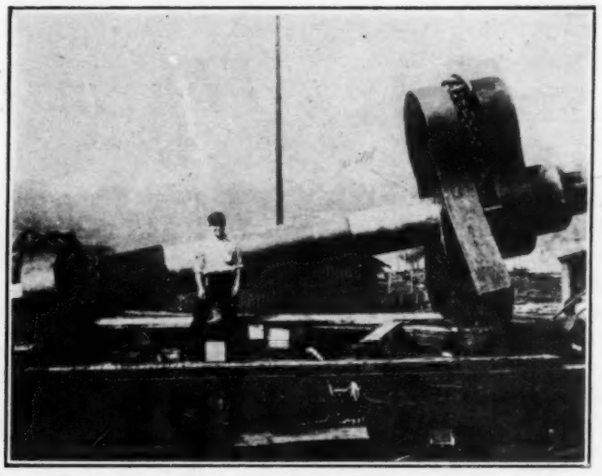

FIG. 6

enormous amount of spares. Steel companies are continually searching for ways and means to reduce their inventories. A properly organized welding department offers one of the solutions to this end. The following illustrations cover some of the large successful Thermit welds in the Iron and Steel Industry:

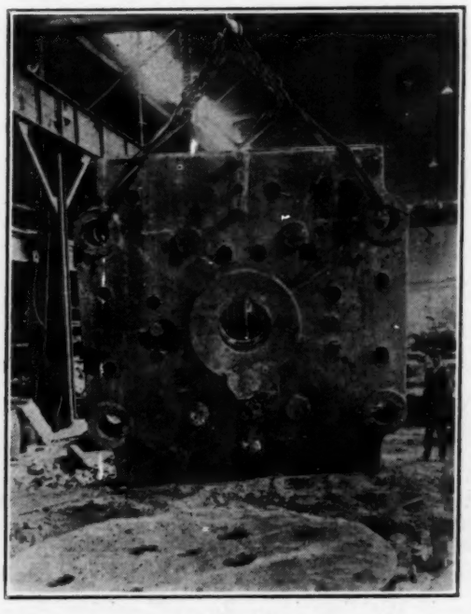

FIG. 7

Fig. No. 1, shows a 26 in. diameter straight shaft with mold box in place. Fig. 2 is the same shaft after having been successfully welded with thermit. It required about 3,000 lbs. of thermit and about 48 hours

preparation to successfully weld this shaft. This shaft is in use at one of the American Sheet & Tin Plate company's plants.

Fig. No. 3, shows broken tooth in 48 in. blooming mill pinion ready for Thermit Weld.

Fig. No. 4, shows same pinion, with furnace for pre-heating, mold box and crucible in place, also welded

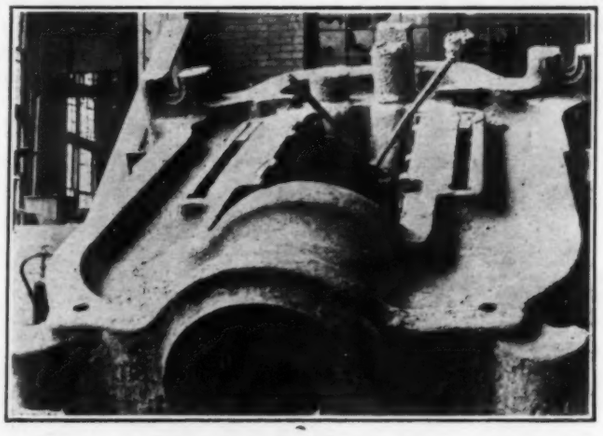

FIG. 8

tooth. The only remaining work on this tooth is cutting off gate and riser. This pinion was Thermit welded for the Pittsburgh Steel Company, Monessen, Pa., Sept., 1914.

Fig. No. 5, shows neck Thermit welded on a 48 in. blooming mill pinion, collar turned off, showing perfect weld. Weld made August 19, 1916, for the Pittsburgh Crucible Steel Company Midland, Pa.

Fig. No. 6, shows 22 in. shaft Thermit welded at edge of crank disc. New forging was made and Ther-

FIG. 9

mit welded to end of shaft. Welded for the American Sheet & Tin Plate Company, Vandergrift, Pa., September 27, 1918.

Fig. No. 7, shows large platen Thermit welded for large hydraulic press, for Cambria Steel Company, Johnstown, Pa., May 26, 1918.

Fig. No. 8, shows two Thermit welds made on cast steel housing for the West Penn Steel Company, Brackenridge, Pa., August 20, 1918.

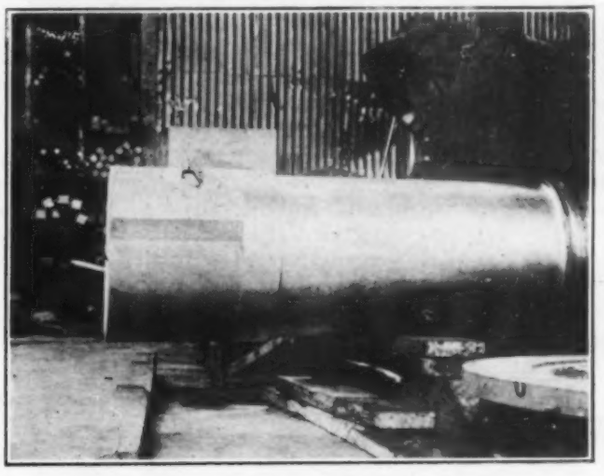

FIG. 10

Fig. No. 9, shows drive end of 25 in. diameter blooming mill crank shaft Thermit welded for the Bethlehem Steel Corporation, Steelton, Pa., October, 1918.

Fig. No. 10, shows same shaft, finished weld after machining.

Fig. No. 11, shows finished Thermit weld on large alligator shears welded for the Joseph Joseph Company, Coatesville, Pa., Welded January 21, 1918.

In conclusion wish to say, there are very few broken sections around a steel mill that could not be successfully and economically Thermit welded. In

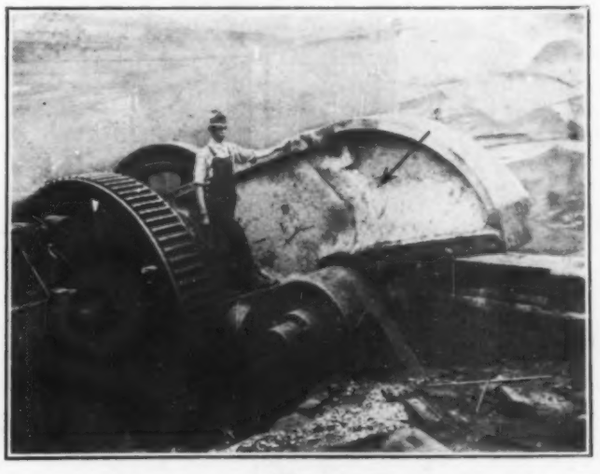

FIG. 11

many cases spare parts are not carried in stock, which take weeks to make, so why not reclaim your broken parts by welding?

*Cutting Steel Mill Maintenance Costs with the Welding Arc**

By A. M. CANDY†

IT MAY be stated without fear of contradiction that there is no industrial plant in which the tools of production are subjected to such strenuous service and result in a greater loss financially due to a forced shutdown, than a modern steel mill. It is for these reasons that the steel plant maintenance departments are always keen for any processes or apparatus which will enable them to expedite repairs, especially, if the repaired equipment will give equal or greater life than the original equipment.

By using the arc welding process the steel mill operatives have discovered for themselves a number of facts:

1—A great many repairs can now be made which were previously impossible.

2—The cost of making numerous repairs has been materially reduced, sometimes to 10% of previous costs.

FIG. 1

3—The time required to make various repairs has been reduced.

4—The life of certain repaired parts is greater than the life of the original parts.

5—A large number of repairs can be made on auxiliary equipment, such as steam locomotives.

One of the most remunerative repair jobs received by the welding department is the steel mill driving spindle the pods of which become rapidly worn in service by the coupling box pods. Fig. 1 and Fig. 2 show one of these spindles before and after building up

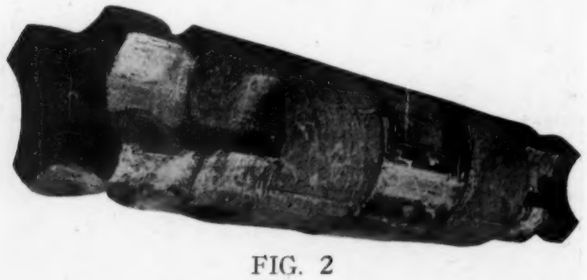

FIG. 2

the pods. These spindles will cost several hundred dollars apiece and can be reclaimed for $25 to $50 apiece, depending upon the size. The wear on these pods is principally an abrasive action and, therefore, to obtain the maximum life it has been found that a deposit of high manganese steel properly quenched gives the best results. When the pods are badly worn, low carbon

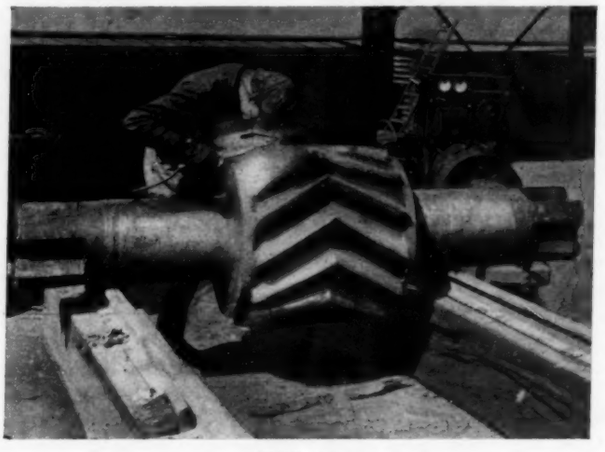

FIG. 3

steel is used as a base and the high manganese material is only used for the last ½" to ¾" layer. In many cases it has been found that pods built up in this manner will outwear the original steel casting.

Steel mill pinions represent a much more remunerative salvaging opportunity, as they are much more expensive, running about $2,400 for a 46,000 lb. pinion. Not only can the pods on the pinion ends be built up but worn or damaged teeth can also be repaired as per Fig. 3.

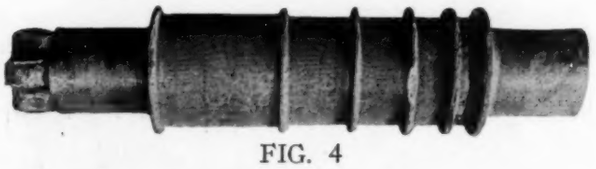

FIG. 4

It is not uncommon for collars on rolls to become chipped or in some cases badly broken. These can

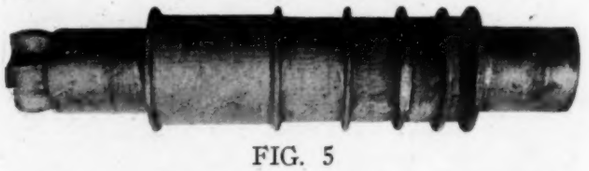

FIG. 5

be readily restored to service as shown by Fig. 4 and Fig. 5.

By continually repairing pinions, rolls and spindles one plant has found it unnecessary to buy any new parts of this type for a period of five years which will probably be extended eventually.

*Presented at Pittsburgh, December 13, 1924.

†Engr., Welding Dept. Westinghouse Electric & Mfg Co., East Pittsburgh, Pa.

Fig. 6 shows an open hearth cooler prepared ready for welding and Fig. 7 shows the cooler welded, ready for service.

One very striking example of the savings which can be made with the arc process of welding is that of a 1500 H.P. vertical blower engine cylinder which

FIG. 6

was cracked and welded several years ago. This cylinder had a bore of 80" and a stroke of 60", and was cracked on two opposite sides a distance of 3½ feet and five feet, due to the piston assembly becoming loosened on the piston rod. The price of a new cylinder at the time of the accident was $12,000 and the manufacturer wanted nine months for delivery of a new cylinder. The two cracks were prepared for welding as shown by Fig. 8 and finished as per Fig. 9. This was all accomplished with a minimum amount of disassembly of the engine, as no preheating of the parts is necessary with the arc welding process. The cylinder was rebored to clean up some score marks. A few scores were so deep however, that it was necessary to weld them up also, after which the excess metal was ground off. This entire job required 327 man hours and involved an expenditure of $737.20 as compared

FIG. 7

with 9 months to deliver a new cylinder at a cost of $12,000 which does not include the cost of the necessary complete dismantling of the engine and the installation cost of the new cylinder.

Practically all large steel plants have rolling stock including cars and locomotives of both narrow and standard gauge. There is inherently a great deal of maintenance work on this equipment which can be done more economically with the electric arc. For example sharp flanges on car wheels and locomotive drivers

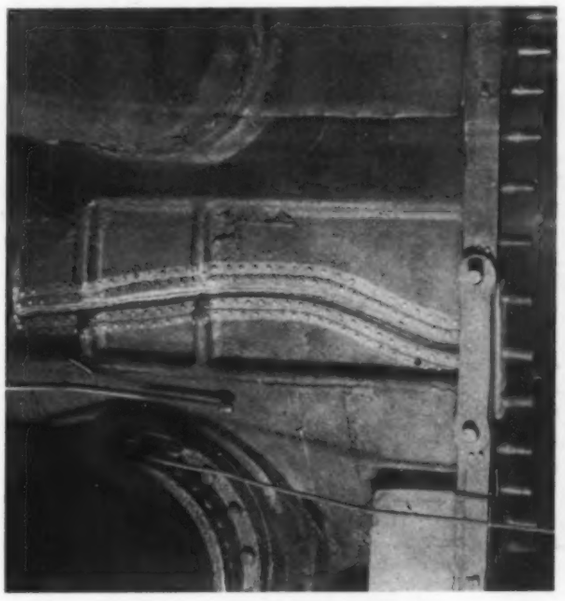

FIG. 8

can be built up to normal gauge without removing the wheels and without requiring any finishing operations as illustrated by Fig. 10. A 36-inch diameter wheel can be built up with four complete strings of deposited metal using 160 amperes and 3/16" high carbon wire in approximately three hours.

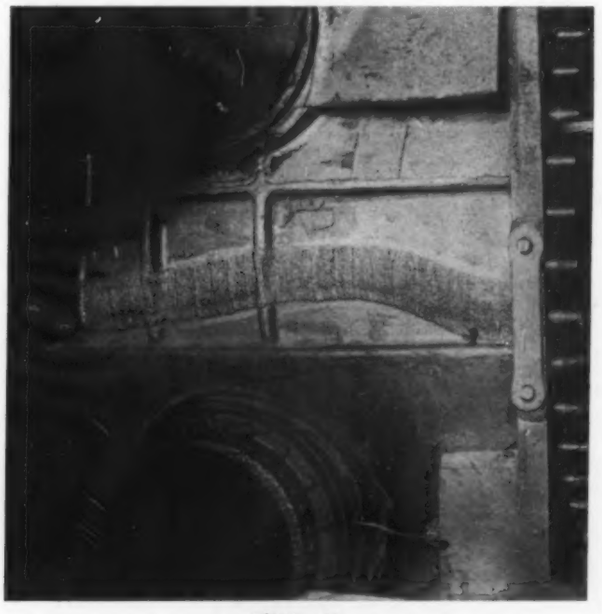

FIG. 9

A very appreciable saving can be made in locomotive firebox work which includes completely welded fireboxes; welding flues to rear flue sheet as per Fig. 11. In addition patches can be readily applied to side

sheets and door sheets. Cracked cylinders can be readily repaired and broken frames can be welded in many cases without dropping the wheels.

In the yards special track work can be built up and ground to original contour such as switch points, frog points, crossings and battered rail ends.

To carry on welding work in a steel plant it is usually advisable to establish a central welding depart-

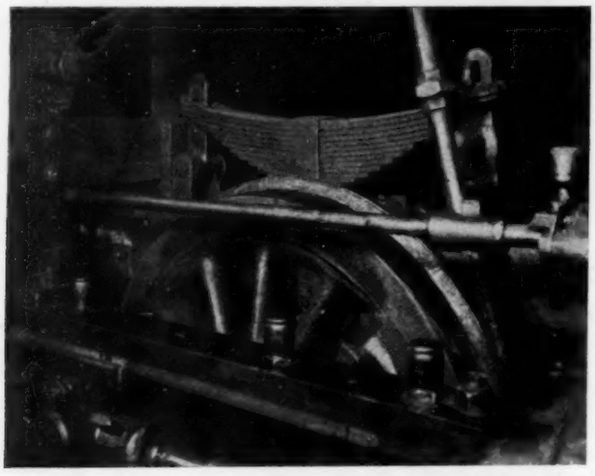

FIG. 10

ment where a majority of the work can be brought for repair. For such an installation one or more motor-generators of the multiple operator type of about 500 amperes or 1,000 amperes capacity at 60 volts are usually used. These equipments, with proper control panels, will provide welding current for a number of operators working from a single machine. Where it is necessary to take the welding equipment to the work a multiple operator portable set Fig. 12 can be used where capacities of 300 to 500 amperes are required.

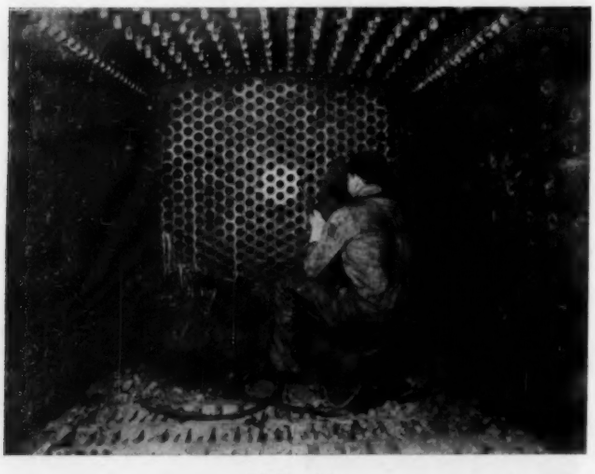

FIG. 11

Where only sufficient capacity for an individual operator is necessary the portable single operator type of equipment Fig. 13 may be used. When an equipment of unusual light weight is desired and where D.C. service is available at 500 to 600 volts a resistant welder weighing 160 pounds Fig. 14 can be used and carried easily by two men, one at each end. If the

FIG. 12

D.C. service is 230 to 275 volts a much lighter equipment weighing 60 pounds may be used and carried by the operator.

SUMMARY

To summarize briefly it is possibly advisable to give a list of work which can be arc welded.

1—Pods on spindles and pinions.
2—Teeth on pinions and gears.
3—Broken collars on rolls.

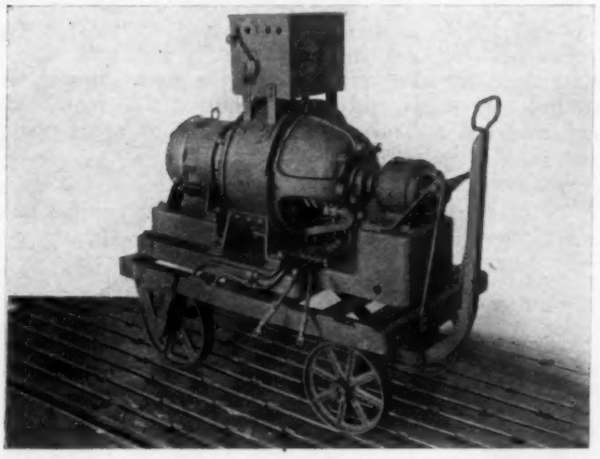

FIG. 13

4—Open Hearth port coolers.
5—Cracked blower engine cylinders.
6—Cracked steam hammer cylinders.
7—Ingot stripper rams.

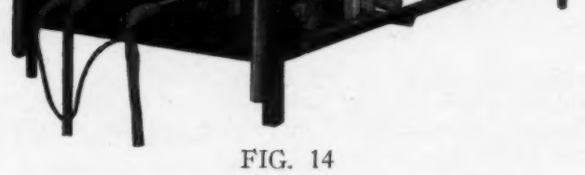

FIG. 14

8—Furnace doors and frames of steel.
9—Open hearth furnace reversing valves.
10—Worn blooming mill housing keyways.
11—Worn jaw clutches for motor driven shears.
12—Worn "Crabs" on rolling mill engines.
13—Steel oil drums.
14—Pipe manifolds.
15—Building mill stoves replacing salamanders.
16—Steam pipe line brackets.
17—Repairing defective forgings.
18—Worn swagging dies.
19—Locomotive driver flanges.
20—Car wheel flanges.
21—Locomotive frames.
22—Locomotive flues.
23—Locomotive fire boxes.
24—Locomotive fire box patches.
25—Locomotive cylinders.
26—Locomotive main rods built up.
27—Locomotive side rods built up.
28—Locomotive cross heads built up.
29—Locomotive piston rods built up.

*Pipe Line Arc Welding**

By R. R. APPLEGATE†

AN exhaust steam line consisting of 800 feet of 30-inch and 400 feet of 28-inch and 24-inch pipe, in which the circular joints, saddles and angle flanges were Electric Arc welded, was just recently put into service at the Mingo works of the Carnegie Steel Co.

At first, there seemed to be some doubt among the engineers as to the advisability of Arc welding this line; but an inspection of the finished job would convince even the most skeptical, that for this class of work riveting has lost its prestige, and that welding is not only practicable, but desirable.

The pipe for this line was furnished by the National Tube Co. and was made from 5/16-inch mild steel hammer welded.

FIG. 1

The welding was carried out by the Welding Equipment & Engineering Co. of Cleveland, using the Liteweld dynamotor type portable welder.

Fig. 1 shows the equipment and the operator at work.

Free flowing low carbon steel electrode 5/32" in diameter, was used in welding the circular joints and saddles, and 3/16" mild steel in welding the angle flanges. About 625 pounds of metal was deposited, and the work completed in 250 working hours, giving an average deposition of 2½ pounds of metal per hour. The fact that the welder could be easily moved from place to place by one man, eliminated the necessity of handling long welding cables and aided considerably in speeding up the job.

*Presented at Pittsburgh, December 13, 1924.

†Welding Equipment & Engineering Co., Cleveland, O.

Fig. 2 shows a 100-foot section being hoisted into place by the crane. As a matter of curiosity to know whether or not the welds would withstand the strains, this particular section was first lifted by

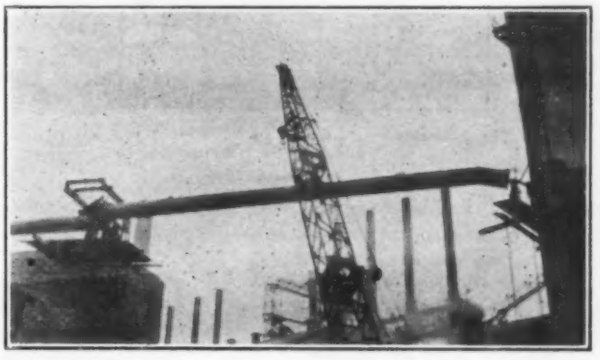

FIG. 2

attaching the spreader immediately back of the end circular joint. This induced a tension stress of about 55,000 pounds per square inch in the topmost fibers of the world without any signs of failure.

Another view, Fig. 3, shows the above-referred-to section in place, and the operator making a flange

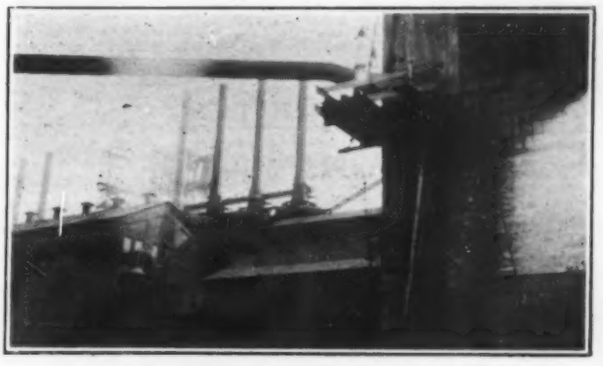

FIG. 3

weld which was not done on the ground, owing to the difficulty of properly setting the flanges. Note the 48-inch stand pipe which has a welded circular joint.

Fig. 4. Operator welding cir. st.

Fig. 5 is a close-up view of a welded joint and an angle flange. It will be noted that the flange extends about ½ inch beyond the end of the pipe,

FIG. 4

which was inside beveled 45 degrees to facilitate welding.

Fig. 6 is another view of the operator making an outside weld on the flange.

Fig. 7 shows a 90-degree bend in the line where the flanges were also welded after erection, because

FIG. 5

of the difficulty of properly setting the same. The circular joints here shown were also re-enforced with a light weld on the inside of the pipe because of the fact that the sections lined up poorly, leaving in many places an opening of ¾" to be bridged by weld metal.

A view of a section of the completed line showing the method of suspension is shown in Fig. 8. Note the 8-inch manhole, of which there were seven, together with numerous other take-offs, ranging in size from a 5-inch tee connection to a 28-inch branch-off at 30 degrees.

The advantages of welding over riveting this line may be summarized as follows:

Owing to the elimination of the internal friction due to rivet heads, welded pipe could be made 2

FIG. 6

inches smaller in diameter, which, coupled with the lower cost of hammer-weld pipe, resulted in considerable saving.

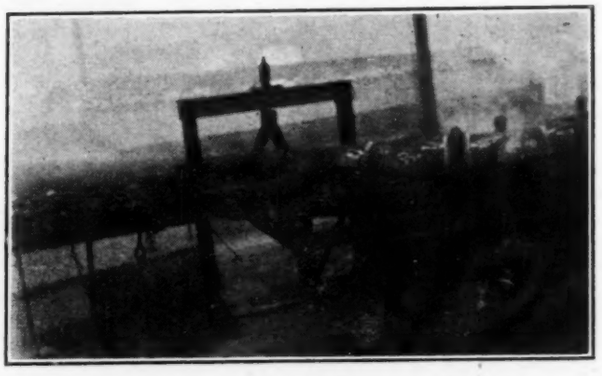

FIG. 7

In as much as a 16-inch pipe line is to be suspended from this line, the strong, permanently reliable joints desirable were assured by welding.

There was a saving in cost of welding over rivet-

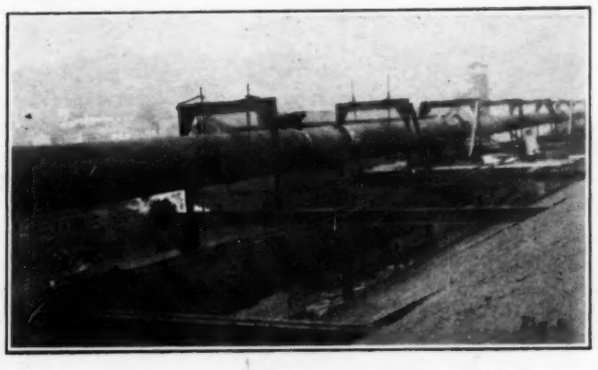

FIG. 8

ing and the job was completed and put into service in a shorter time than it would otherwise have been.

The caulking invariably necessary to stop leaks in a riveted line is done away with by welding.

*Production of Oxygen From the Air**

By DON B. McCLOUD†

THE industrial uses of oxygen began their rapid development almost fifteen years ago. The oxy-acetylene welding torch and the cutting torch opened a vast field of economy in the metal fabricating industries and engineers quickly realized the enormous savings that the uses of oxygen could effect in practically every branch of the metal trades. Gas welding and cutting now is a part of modern shop practice.

Few industrial expansions of comparable magnitude have attracted as little general attention as that which has taken place in the oxygen industry during the last fifteen years. In 1909, less than four million cubic feet of oxygen were produced in this country. In 1919, only ten years later, the production was well over one billion cubic feet. The annual oxygen bill for American industries is well over ten million dollars, of which the steel industry pays a large share; consequently, it may be of interest to look beyond the familiar oxygen cylinder and see just how the content of that cylinder is produced.

Pure oxygen is seldom encountered in nature, but in a combined or mixed state, oxygen is the most widely distributed of all the elements. The air we breathe contains about 20% oxygen. Water is approximately seven-eighths oxygen by weight. Air and water are the two great reservoirs of oxygen, and it is only logical that a commercial oxygen plant should draw on one of these reservoirs for its supply of raw material.

The production of oxygen from water is accomplished by electrolysis. When an electric current is passed through water in which has been dissolved caustic soda or some other electrolyte, the water decomposes into its component elements, namely, oxygen and hydrogen.

Most of the oxygen used today, however, is produced from the air by what is known as the liquefaction process. Air contains about twenty per cent oxygen and eighty per cent nitrogen. The problem of separating pure oxygen from the air has been solved in the construction of apparatus that first liquefies the air and then allows the nitrogen content to gasify or boil away, leaving the oxygen.

The process is based upon two well-known physical principles; first, that air, a mixture of gases at ordinary temperatures, will liquefy if sufficiently cooled; and, secondly, that if a mixture of two liquids is heated, the one with the lower boiling point (nitrogen in the case of air) will assume gaseous form first, leaving behind the other liquid (oxygen), which has a higher boiling point.

To illustrate this process of liquefaction, consider the case of steam, which is a gaseous form of water at temperatures exceeding 100°C. When steam is cooled below its critical temperature, it turns into a liquid, water. Air has exactly the same physical characteristics. It is gaseous at ordinary temperatures, however, but when cooled to 194°C., it condenses into liquid air in exactly the same manner as steam condenses into water.

The extremely low temperature required in order to produce liquid air is accomplished by allowing compressed air to expand within a heavily insulated chamber or column. Some idea of the refrigerating effect of expanding air can be gained by slightly opening the valve of an oxygen cylinder and holding your hand in the stream of escaping gas, which will be found to be very cold.

Once liquid air is produced, the separation of the oxygen content is effected by a simple process of distillation, taking advantage of the temperature gradient between the boiling point of oxygen (—182°C.) and nitrogen (—194°C.).

In outline, the process is exceedingly simple. Air is purified, compressed, dried, liquefied and distilled. Each step of the process, however, has features that merit detailed consideration. Certain amounts of carbon dioxide and water vapor are contained in ordinary air, and these must be removed before the air is liquefied, as they would become solid at the low temperatures and thereby cause trouble by blocking pipe lines. The purifying towers, connected in series, remove the carbon dioxide. Air from the outside is sucked through the intake pipe by the action of the air compressor, and enters at the bottom of the first tower. In ascending, the air comes in contact with a solution of caustic potash, sprayed from the upper part of the tower and flowing down over closely packed baffling devices. Thus there is a constant stream of air passing upward through the baffles and a constant stream of caustic solution trickling downward and absorbing the carbon dioxide content of the air. After the air leaves the top of the first tower, it enters the bottom of the second tower, where the process is repeated. The caustic solution flows to a reservoir in the base of each tower, from which a pump returns it to the sprays.

As might be expected, the air compressor is really the heart of the system, because steady production is absolutely dependent upon a compressor that will work 24 hours per day, seven days per week, without a hitch. The compressors used in a liquefaction plant have been developed especially to meet the severe service requirements imposed upon them. During the starting period of approximately an hour and a half, a pressure of 200 atmospheres, or about 3,000 pounds per square inch, is maintained. After the column is sufficiently cooled, the plant operates normally at a pressure of 50 atmospheres, or about 750 pounds per square inch.

A four-stage compressor is used, whereby the air is boosted in four successive steps or stages. Following each stage of compression, the air is cooled by appropriate inter-coolers. The efficiency of this cooling is such that the air leaves the compressor under 3,000 pounds pressure at a temperature that closely approximates that of the incoming cooling water.

A unique feature of construction is the absence of any stuffing boxes on the compressor. All sliding joints are sealed by means of piston rings. The order of stages from the crank end is 2, 1, 3, 4. It is thus

*Presented at Pittsburgh, December 13, 1924.

†Consulting Eng., Burdett Oxygen Co., Pittsburgh, Pa.

impossible for any unpurified air to enter the compressor, even though the piston rings nearest the crank should leak, because the pressure in the second stage is always above atmospheric. Air can enter only through the first stage inlet valve, which, of course, is connected to the pipe leading from the purifying towers.

Some oil is naturally entrained in the air during its passage through the compressor, and this, together with the moisture content, must be eliminated before the air is ready for liquefaction. During compression, some of the water vapor condenses in the intercoolers and is blown off at intervals. The remaining water vapor and entrained oil are removed by means of a purging flask and drying battery. The purging flask is merely an empty cylinder through which the air passes. The sudden reversal of flow and decrease of velocity cause precipitation of the oil mist and much of the water.

Remaining moisture and any remaining traces of CO_2 are removed in the drying battery, which consists of three steel cylinders containing walnut-size caustic potash, through which the air passes in series. An additional battery is provided, so that the drums of caustic potash may be changed without interrupting the process.

From the drying battery, the air passes to the top of the liquefaction column. This column consists of an inner chamber about one foot in diameter, separated from the outer shell by suitable insulating material. The upper portion is a heat interchanger. About the center is an expansion valve and below this a series of baffle plates, over which the liquid air flows to the reservoir at the base.

The purified compressed air enters at the top of the heat interchanger, and as it passes downward, its heat is transferred to the nitrogen gas that is leaving the column. The air then goes through a coil in the liquid reservoir at the base, where it is further cooled. Then it arises to the expansion valve, where the pressure is suddenly reduced to about five pounds per square inch, which is the pressure usually maintained in the chamber of the column. Assuming that the column is in regular operation, the space below the plates contains pure liquid oxygen. This is being boiled by the incoming air in the coil, so that oxygen vapor is bubbling up through the liquid air descending on the plates. As the ovygen vapor condenses in contact with liquid air, its heat of vaporization is transferred to the liquid air, which, in turn, vaporizes its more volatile content, which is nitrogen.

Therefore, pure liquid oxygen collects in the liquid reservoir, while the nitrogen containing only a small percentage of oxygen passes out of the column as a gas at the top, after serving to pre-cool the incoming air in the heat interchanger. The liquid oxygen rises in another pipe to the heat interchanger, where it gasifies. Heat interchange has been worked out so efficiently that both the oxygen and the nitrogen leave the column at almost room temperature.

The oxygen passes through a meter into a bell type gasometer, from which it is drawn off by a three-stage oxygen compressor and compressed into cylinders.

DISCUSSION

W. T. Snyder:* One of the welding processes that give large returns is the welding of mill pinion shafts, spindles, rolls, etc.

Pinion shafts, weighing up to ten ton, become worn at coupling boxes and are built up with the electric arc at a very small cost. After rebuilding, the original service is duplicated.

Scrap Open Hearth Steel, of about .11 carbon, is used in rebuilding the worn parts. Carbon Electrodes,

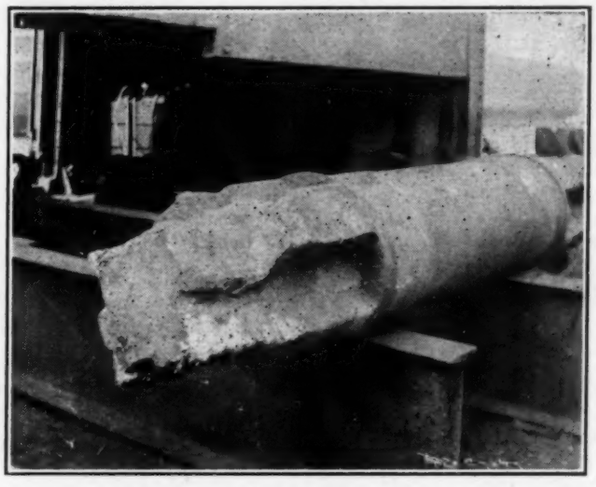

FIG. 1—Large mill spindle showing worn pods, set up ready for welding.

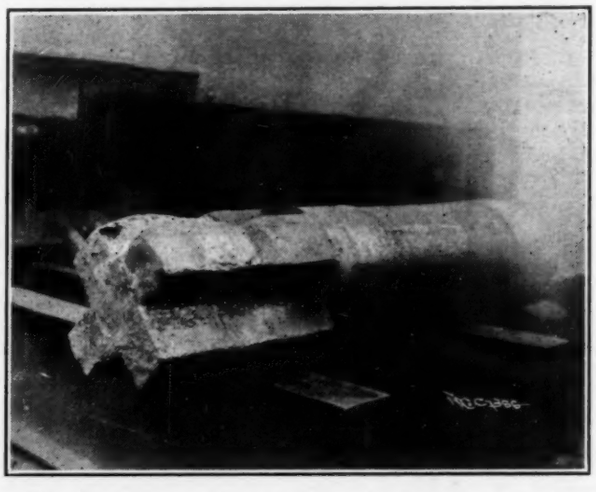

FIG. 2—Large mill spindle after welding. Weight 3,300 lbs.

1 in. by 9 in., are used, the current being 300 to 450 amperes.

Resistance in series with regular 250 volt current is used, sectionalizing switches being used to bear the current.

The Metal Pencil Electrode is used where a small amount of metal is to be built up. More accurate control of the arc can be had with the metal pencil electrode than with the larger carbon electrode.

*Elec. Supt., National Tube Co., McKeesport, Pa.

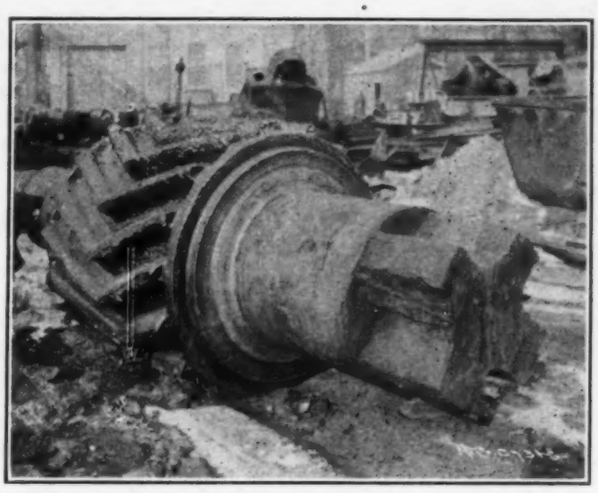

FIG. 3—Large mill pinion showing worn pods on shaft.

FIG. 4—Mill pinion after welding. Weight 18,000 *lbs.*

*Discussion: Electrically Heated Soaking Pits**

A. C. Cummings:‡ We have heard Mr. Bailey's excellent paper and have seen some photographs and drawings which I believe have never been shown in public before. From what I had been told previously to hearing the paper regarding the construction of these pits, I was surprised to see how simple the construction was. I was talking to Mr. Bailey shortly before the meeting and asked him some questions about the electrical conditions. One point which was interesting was the fact that the heating current is supplied to the furnace at comparatively high voltage. Mr. Bailey said in the case of the Donner Pit, the heating elements were operated at 150 volts and that only 150 K.W. was used. Most of us who are familiar with electric furnace operation are accustomed to lower voltages and larger values of current, and in order to use these large values of current the electrical engineer must so design his low voltage connections that their reactance is low in order to keep the power factor high. When power is purchased, the question of low power factor becomes a handicap in the cost of operating such a furnace.

Another interesting fact was that the power factor actually is very high. I had previously been told that the power factor was somewhere in the neighborhood of 50%, and if such was the case, Central Stations would penalize such loads with a high power rate. Mr. Bailey stated power factor was so high they did not bother measuring it and in some installations was as high as 96 to 97 per cent.

I feel there are so many gentlemen here capable of discussing the construction of this furnace from the standpoint of the steel producer that I had better not take up any more time talking about electrical features.

W. P. Chandler, Jr.:† Some time ago I became interested in electrical soaking pits purely from the heating standpoint. Being a fuel engineer, I was very much interested in the possible saving, especially since investigations showed that the efficiency of gas fired pits ranged anywhere from zero to 25%. The zero value is not as bad as it sounds. It means the ingot in itself had sufficient heat when placed in the pit to bring it up to rolling temperature. In other words, no time was lost in getting the ingot into the pit and it heated throughout to a uniform temperature. Under such conditions when so little heat of the furnace is absorbed by the steel, there seemed to be a greater possibility of saving. An analysis of losses shows that approximately 50% is due to the stack and the rest to radiation. In the electric pit there is no stack, so the stack loss vanishes. The radiation from the ordinary soaking pit with relatively thin walls with a large exposed surface, bad checker chambers, flues and everything amounts to a good deal. If we can get away from checker chambers, flues and stack we have conserved a great deal of the radiation, and if proper insulation and proper thickness of walls are used in the construction of the pit, total radiation could be brought down to a normal figure, since the temperature of the pit is not exceptionally high. Seldom is it necessary to carry a soaking pit over 2,500 to 2,600 deg., normal rolling temperature being usually from 2,100 to 2,200 deg. It was a surprise that Donner was heating to 2,300 deg. in average practice; that is probably due to local conditions.

With the high heat losses of the gas fired pit staring us in the face, we started investigating the possibilities in an electrical pit. Mr. Bailey's pit was the only one and is the only one that is on the market at present time, but there seems to be some trouble even there. I was surprised to hear the statement in Mr. Bailey's paper that no trouble had been experienced with the wall that protected the heating elements from being damaged by the ingots. It was my understanding at first that some refractory trouble had been experienced; however, he has been in close touch with it and can probably explain the matter later on.

*Discussion presented in connection with Mr. Bailey's article appearing in February issue of Iron & Steel Engineer.

‡ Elec. Engr., Carnegie Steel Co., Duquesne, Pa.

†Special Engr., Carnegie Steel Co., Pittsburgh, Pa.

The cost to heat a ton of steel in a gas fired pit is around 15c a ton of ingots. Donner is at times heating the steel with 75 K.W. hrs. with Niagara power at ½c per k. w., which is 37c. So there is not so much discrepancy there. In Pittsburgh, with the cost of power double this amount it is different, so some saving will have to be shown before the electrical pit can compete with gas fired pit. However, there is a big field to work in, and the possibilities are great; the power required to roll being cut down one-third, saves about 13 k. w. per ton of the power bill, which can be credited to the pit, and if sound steel can be produced by this method it would be a very great argument.

A. C. Cummins: I happened to be with Dr. Unger a few nights ago and he discussed some of the points made in this paper, and among other things he said, Electrical Engineers install excellent heat insulating material on Soaking Pit Furnaces, put on a perfectly tight cover, then heat it electrically. The results are compared with a gas pit of 25 or 30 years of age upon which no particular pains to conserve heat lost by radiation is taken. He seemed to be of the opinion that if a gas heated pit was put on an equal basis from a radiation loss standpoint that the efficiency might be very much improved, and the statements made regarding the comparative costs between the gas fired and the electric pit would no longer obtain.

W. Trinks:† I came to listen and not to talk. While I have had some experience around steel mills, I came here to learn tonight, and not to show any little knowledge I might have on that subject.

With regard to soaking pits, I am firmly convinced that if we can get the steel out of the strippers and place them immediately into the soaking pits, we would need neither gas fired pits nor electrically heated pits. As a rule, mills are provided with insufficient capacity of soaking pits because they were designed for Bessemer practice. What happens when two or three open hearth furnaces tap at about the same time? Then you have a lot of ingots in the ingot molds standing out in the yard where they become cold. Now all you need to do in order to cure the trouble is to double the capacity of the pits. It does not make any difference whether you heat them electrically or with gas. As soon as you double your pit capacity you will show a great saving in the cost of both heating and rolling, because you do not put cold ingots in the pits. You put in hot ingots, because there is a place where you can put them while they are hot; and therefore, you have no bone in the ingots later on when they go to the blooming mill. With all due respect to our friend, Bailey, and in the esteem of the good work he has done, it may have happened that by the increase of the capacity of the pits he produced a reduction in the cost of rolling. I know a concern where the capacity of the pits was doubled and where the power for rolling was reduced. They were gas heated. This in itself is no argument against the electrically heated pit. I am for it, provided you can put the ingots in hot, but again, if you put them in hot and can do so all the time, you don't need any heating at all. I am over-drawing things on purpose, but I wish to point out that we should have enough soaking pit capacity in any mill, and the fellows who lay out the mills and soaking pits should see to that, instead of copying from converter practices. It is, of course, desirable to provide heating, whether it be electrical or otherwise, to counteract variation losses during those periods when pits are empty or when no rolling is done, as for instance, over Sunday. For that purpose, electrical heating is very well adapted in my opinion, but I should hesitate to bring cold ingots up to heat, because I am afraid that the capacity of the power plant required for that purpose would be prohibitive. For a mill of 100,000 tons per month capacity, it would take a power plant of 50,000 k. w. capacity for electrical heating furnaces and electrical soaking pits, and even the most ardent and zealous electrical enthusiast would hesitate before putting in 50,000 k. w. capacity in addition to that required for the rolling mill drives, for electrical heating. I think we ought to have both gas fired soaking pits and electrical heated pits in each plant; whether the carbon resistor will be the best solution or the silicon carbide resistor or the induction principle, that remains to be seen.

A. C. Cummins: In connection with heating cold ingots, so far as soaking pits are concerned, the heat required is generally over Saturday and Sunday, and usually at that time we have idle power plant equipment available. In other words, it is at the period of off-peak demand, and it might help the fellow who is interested in keeping his electric power costs down to heat a few cold ingots on Sunday.

W. Trinks: We also have coke oven gas to spare on Sunday.

John Lloyd:* I have had the pleasure of reading many of the magazine articles written by Prof. Trinks but have never met the real man until this evening. I would like to say that I think all the men here this evening, who are in charge of blooming mills, appreciate the sympathy shown them, in the remarks made by Prof. Trinks, in regards to the operation of Soaking Pits.

We have had quite a little discussion, tonight, with reference to scale on ingots; whether heavy scale is of a benefit to ingot or whether scale is harmful.

My own feeling in this matter is that the scale on ingot can be summed up as a decided loss, represented by the amount of metal carried away from the ingot by the scale.

By those who claim that the heavy scale is necessary to remove the defects from surface of ingot, the claim is of course made that the scale is of a great advantage. Perhaps the scale does remove defects which appear on surface of ingot but does it not, at the same time, uncover the defects of the layer underneath? The matter of surface defects on ingots is a matter for correction by steel maker, and not a matter of subsequent removal by any treatment at soaking pits or in rolling processes.

Mr. Bailey's figure of loss by scale of 2.75% is very close. Scale loss and other unaccounted for losses will run very close to this figure.

As to Mr. Bailey's statement that the power required for rolling an electrically heated ingot being less than that required for rolling an ingot drawn from a gas fired pit, I can not agree with him because to do so would be to state that it is impossible to properly treat an ingot in a gas fired pit. This statement would be incorrect. The electrically heated pit shown here tonight, and the one under discussion, is built to prepare only two ingots. We could build a very fine gas

†Prof. Mech. Engr., Carnegie Institute of Technology, Pittsburgh, Pa.

*Blooming Mill Supt., Carnegie Steel Co., Braddock, Pa

fired pit to handle only two ingots at a time. Until the electrically heated pit is put under the same strain and on same working conditions as the gas fired pits now in use, we must be very careful as to any claims made for it, especially as to statement that less power is required for rolling.

Most certainly the power required for rolling is a matter of temperature of ingot and not a matter of the means by which that temperature has been attained.

The introduction of electrically heated pits will mean a great saving in repair costs, which now in many plants runs as high as 60% of the fuel costs. The elimination of checkers, flues, reversing valves, stacks, gas producers, gas lines, etc., can not but reflect a great reduction of repair costs. There would also be a reduced operating cost owing to reduced need of bottom making.

The thing I fear most, judging from the few pictures shown here this evening, is the mechanical construction of these electrically heated pits. We have cranemen for handling ingots at our plant equal in ability to those found at most plants, but I would certainly not like to trust this pit to them. It is very well to have only one pit and that one put under special observation, where every move will be directed and where the cranemen will do all in their power to save every bit of wear that they can, but the condition is very much changed when the strain of present day operating conditions are imposed on the pits. Where we must move along quickly even though some damage be done to our equipment.

I do not think that this electrically heated pit will stand the strain.

I hope that soon we can attain to the electrically heated pit, so constructed that we can operate it under the same strain and conditions as we now do the gas fired pit. It will be only through this sturdy construction that we can ever hope to put the electrically heated pit alongside of the gas fired pit for commercial operation.

R. S. Shoemaker:* I did not expect to say a word, but I certainly have enjoyed the paper. The electric heated soaking pit is something we have all been thinking about for a number of years, wondering if it would ever come, and it certainly looks as though it may some day. I would like to know how often you have to renew your carbons; what that amounts to in cost; if it is an item worthwhile or not? I would also like to know something about refractories; whether standard soaking pit refractories are used, or something special?

E. G. Crozier:† I would like to know something more about the finished product; blooms; and cost of chipping, if there is such data to be given out. Give us something in dollars-and-cents equivalent that an electric lay-out would cost as compared with by-product heating pits.

D. M. Petty:‡ The electrically heated soaking pit should, from an efficiency standpoint, be a particularly attractive installation, as the thermal efficiency of any fuel fired soaking pit is necessarily low, owing to the fact that the combustion gases cannot be cooled to any great extent and therefore cannot give up their heat. In any combustion type of furnace there must be a passage of gas from the point of combustion through the furnace to the stack, therefore, high stack temperatures are always found where the steel is put into the furnace at only a few hundred degrees below the temperature at which it is to be taken out of the furnace. In electrically heated soaking pits there is no necessity for passing gasses through the furnace, the furnace can be closed up tight. Therefore, all the heat generated in the furnace is available for use in heating steel with the exception of that which escapes when the doors are opened or through the walls of the furnace.

As pointed out by Mr. Bailey, everyone has hesitated to try the experiment of an electrically heated soaking pit, largely I imagine, on account of the size of the furnace and also on account of the high temperatures which it is necessary to use. The carbon resistor type of furnace has been in use with more or less success for a number of years. One of the inherent difficulties with any carbon resistor in which the carbon consists of small lumps, is to design a trough which will carry this carbon and not be destroyed, either by the heat which comes from the carbon itself, or from the heat which would be generated in the walls of the trough by the current flowing through its walls. Practically all refractories have a negative co-efficient of resistance and become conductors at high temperatures. Therefore, when the resistor reaches a high temperature, the current will divide itself into various paths, inversely proportional to the resistance of these various paths. By using carborundum material in building the trough, the problem is partially solved and if the current will stay in the carbon resistor and in the carborundum material making up the walls surrounding it, no serious difficulty will be experienced, but if the current finds its way into the other refractories with which the furnace is built, trouble will eventually occur and the refractories will have to be renewed. This is a difficulty that is inherent in this type of furnace and must be minimized by careful design.

I feel that both Mr. Bailey and the Donner Steel Company are to be congratulated in making this first installation of an electrically heated soaking pit, and I believe that from this installation sufficient experience will be gained so that a satisfactory design can be made, and once a satisfactory design has been accomplished and tried out, I feel sure that many other installations of electrically heated soaking pits will be made.

Mr. Bailey's comments on the subject of "Scaling Ingots" I am sure, will be of great interest to all manufacturers of steel, and possibly some means will be found to eliminate the necessity of heavy scaling for the purpose of securing a good surface on the rolled product.

In the application of electrically heated soaking pits as a load for the power system in a steel plant, it should be noted that an intermittent supply of power to the soaking pit will not be a serious handicap to the soaking pit unless the intervals of "power-off" are great compared to the "power-on" intervals. Supplying power to an installation of this kind on an intermittent basis will be a very convenient method of improving the load factor of the total plant load and enable a steel plant to supply power to the soaking pit

*Supt. Maintenance, American Rolling Mills, Middletown, Ohio.

†Supt., Struct. Dept., Carnegie Steel Co., Munhall, Pa.

‡Elec. Engr., Bethlehem Steel Co., Bethlehem, Pa.

without increasing its generating capacity. Of course, this feature must be carefully studied so as to be sure that the "off" intervals will not slow down the operation of the soaking pit to such an extent that it will seriously slow down the heating capacity of the furnace and thereby limit the operation of the mill taking steel from this furnace.

I feel that the Association is to be congratulated on having this discussion brought forward at this time and I hope that all the steel mill men present will contribute their ideas both pro and con so that Mr. Bailey and others who are interested in the project will be able to anticipate any troubles that are suggested as possible with an installation of this kind.

I would like to have Mr. Bailey explain what steps he has found necessary to confine the current to the resistor.

How many kilowatt hours are required to bring the furnace up to temperature? This is a measure of the heat inertia of the furnace and will give an indication of the effect of taking power off with steel in the furnace.

How many kilowatt hours per hour are required to maintain a constant temperature in the furnace? This is a measure of the radiation losses.

G. E. Stoltz:* Mr. Bailey has stated that less power is consumed in rolling electrically heated ingots than gas heated ingots. We do not believe there should necessarily be any difference in power consumption, due to the different sources of heat. However, for every grade of steel there is a rather definite maximum temperature to which the steel can be heated. With electrically heated pits the temperature can be controlled very closely and it is possible to keep the temperature of the ingots very close to this maximum safe value. With gas heated pits this ease of control is not obtained and there will be a wider variation of temperature. Therefore, in order to not exceed the maximum temperature to which the steel can be heated the general average in the gas heated furnace must be lower than that which would be obtained in the electrically heated pit. For this reason it is quite possible that the power required to roll the ingots from electrically heated pits would be less than from gas heated pits.

There is often considerable discussion between the rolling mill superintendent and the man in charge of the soaking pits as to whether the steel is being properly heated. With electrically heated pits a graphic chart of temperature of the steel in the pits could be obtained and this discussion to a large measure eliminated. Graphic charts also are of value since they indicate the performance at nights and during periods when superintendents are not present.

In analyzing the costs given by Mr. Bailey comparing electric heating with gas heating, he has used electric power costing six mills per K.W. hour and coal gassified at $6 per ton. These figures seem reasonable for the Buffalo district where Niagara power is used; but if we modify his electric calculations using electric power costing one cent per K.W. hour and $4 coal, the results still favor electric heating. The cost of power from his estimates is not the controlling feature. The most important item is the loss due to scale. If this is true we believe it is rather important to definitely establish the difference in losses, due to scale.

*Gen. Engr. Div., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

The cost values given for the two methods of heating include operating costs only. To make this complete it would be interesting to add to this the fixed charges due to the installation cost.

Professor Trinks has referred to soaking pits where no additional heat is added. The hot steel is placed in these pits and left there a sufficient length of time to allow the heat to become uniform throughout the entire ingot. One of our engineers visited some of the steel plants in Europe approximately a year ago and saw an installation of these pits at the Peine Works where no additional heat is added.

We should recognize that the work being done by Mr. Bailey and the Donner Steel Company is pioneer work and time will be required to solve all the problems. While it may be necessary to grant that electrically heated pits for hot steel is not yet practical, still it may have a very great future. This can only be developed by such work as is now being done by Mr. Bailey and the Donner Steel Company. Ten to fifteen years ago we heard considerable criticism of electric drive for rolling mills. At that time all the problems had not been solved, but if it had not been for those who pioneered the installation of rolling mills we would not be taking advantage of electrification of our plants as is being done today.

A. C. Cummins: Some of the men who operate soaking pits could possibly tell us some very interesting points, perhaps basing their discussion on lantern slides of the ingots we saw.

S. G. Worton:* I have listened to all this discussion, and I think the Donner Steel and Mr. Bailey's Company are to be congratulated. If the Pittsburgh district were paying $6.00 or $7.00 more for coal and getting a good price for By-Product Gas and Coke screenings sold as Domestic Coke, I think we would probably consider the installation of the Electric Pit. One important factor brought out: If you put the ingot in hot and maintain a certain temperature you can have a better rolling than with gas fired pit, because your electric power will hold to a certain temperature. Your refractory cost, due to abuse from inefficient operation will affect it some. This has all been very interesting to me."

F. F. Slick:† I did not come here to "bury Caesar, nor to praise him." But I have been very much interested in what has been said in regard to this electric pit installation, and have listened with a great deal of pleasure to the paper and discussion, and the various things that have been contributed to the subject and to the many trials and tribulations we have in the steel business. Mr. Lloyd has mentioned quite a few with which I am very familiar. I do not know that I can really add anything to what has already been said except to congratulate the Donner Steel Company, as well as Mr. Bailey, for this pioneer work. All pioneers are to be congratulated and encouraged with the hope that they will finally arrive.

There is quite a lot of consideration to be given the electric soaking pit. I can readily see in its early stages of construction some of the difficulties which Mr. Lloyd has mentioned and some of the difficulties mentioned by other speakers, and I am taking our case as an example. At Edgar Thompson Works, where we have soaking pit capacity for 192 ingots,

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†Oper. Supt., Carnegie Steel Co., Braddock, Pa.

8 rows of pits, 24 to the row. We have cranemen equal to any, but when these men are handling 4,500 tons of ingots every day of 24 hours, they aren't likely to be so very careful about their work. The craneman isn't caring whether he gets the right hold on the ingot or not, his idea being to get it into the pit, get it out again, and get it into the mill, with the result that many ingots fall and I do not know what would happen to a construction of this sort. I am very much interested in the up-keep of the soaking pit, as it is one of the bugbears in mill practice, and I would like to hear more along the lines of construction and the refractories used in the construction of this electric furnace, whether or not any particular kind of brick, other than the ordinary refractory brick has been used; whether chrome, magnesite, or whatever kind. I appreciate that should the electric furnace come, the space required for it will offset a lot of things that we are contending with at the present time, from the fact that it requires very much less space and so many less appurtenances than the gas fired pit.

I can see one point in the remark that was made about requiring less power that might have a bearing in answering some of the questions asked.

The only reason I can advance just now, that the electric heated ingot would require less power to roll, would be from the fact that it would be more uniformly heated throughout than the gas fired ingot. I do not know whether that is right or not, but that is the only reason that I could give for its requiring less power.

I am in sympathy with everything Prof. Trinks has said. He and I used to get together occasionally and always got along fairly well in our discussion pertaining to roll designing.

I want to thank the society for the invitation to come to this meeting, and must say that I am glad to be here and listen to this discussion of Mr. Bailey's paper on a subject of considerable interest to the steel business.

F. W. Cramer:* I think the point Mr. Slick made about the design of this furnace is the right one to take. About 10 or 11 years ago I saw one of the first electric furnaces in the country. We thought it was pretty good, but if you compared that with what they are turning out now you would laugh at it. Donner Steel Company deserves credit for putting this in and letting them try it.

There is one thing we haven't had much discussion on: what the advantage would be in having a uniform rolling temperature. I do not know how close they can control gas furnaces, but this electrical heated furnace can be controlled within 10 deg. Whether that is a big advantage in rolling, I do not know, but when you get down to merchant mills where we have motor-driven mills, I know it is a big advantage if we can control that temperature, because the horse power does rise with the temperature if you get below a certain point.

I would like to congratulate Mr. Bailey and the Donner Steel Company for putting in this installation.

A. W. Soderberg:† Not being an operating man nor an electrical man, I am not prepared to take part in the discussion. It would be interesting, however, to know whether any figures are at hand in regard to upkeep and maintenance of an installation of this kind.

J. G. Horgan:* I have listened to criticisms here tonight, but the developments of the electric furnace are something new, and, of course, everything new comes in for considerable criticism. The mechanical design of the furnace it is hardly fair to criticise, considering it is absolutely new. It will inherently be changed to meet conditions; that always happens. The point that strikes me, as far as the steel man's side is concerned: the cost of this furnace would be composed of operation, fuel, repairs—including the repairs incidental to the fuel production and gas, where it is not electrical—and as to quality of steel produced that comes from the soaking pit. I was very interested in the discussion that has taken place as to the saving in power that apparently exists when you are rolling steel ingots from this furnace as against the gas ingots, and I think that condition, while it did not seem reasonable at first, was fairly well explained by some steel men. I have noticed in the case of annealing on cold rolled stuff; one particular installation I am thinking of now that has been recently installed, where it is electrically annealed, and they get an excellent grain structure, and they are claiming their cost on that steel going through the rolls afterwards is less than before. This sort of bears it out. Looking at it from the standpoint of central station power, to us men who are power producers these loads are very interesting, indeed. Most of them, where central stations are concerned, would come in from customers who are already pretty good customers, and owing to their good load factor, which he maintains would run 90, probably 95, the resultant load factor would inherently have a tendency which would actually reduce their present electric rates considerably. I have talked this over with Mr. Bailey on some other installations, and the central station man can well afford to make rates in the neighborhood of .008 and less in certain cases; one particular case I know the rate would run down as low as .007.

When you figure electric power cost per ton of ingots, fuel cost, and the other factors, such as scale loss and intangibles in the way of less space required, and whatever repairs amount to, I think this cost of electricity, whether .007 or .008, isn't going to be the factor that will determine whether electric furnaces are used or not. I think it will be mechanical design, and I think the Donner Steel Company and Mr. Bailey have a vote of thanks coming to them for the work they have done. There must be some satisfaction to Mr. Bailey in the work he has done.

H. L. Bodwell:† I want to congratulate Mr. Bailey for the results which he has so successfully accomplished in the development of Electrically Heated Furnaces. He came to Vandergrift about ten years ago, as I remember, with designs of furnaces for heating sheet bars and sheets, for annealing sheets, for heating galvanizing pots, and had even at that time a design for electrically heated soaking pits.

I have been hoping ever since that I would hear from Mr. Bailey again and that he had developed something practical in the way of heating ingots electrically

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†Chief Engr., Carnegie Steel Co., Munhall, Pa.

*Gen. Pub. Engr., Ohio Public Service Co., Cleveland, O.

†Asst. Dist. Mgr., American Sheet & Tin Plate Co., Vandergrift, Pa.

that would compare favorably in cost with what we are doing now with gas fired pits.

I question very much if you can improve the quality of steel by any method of heating the ingots in soaking pits, but I know that it is quite easy to do injury at this point by heating them too hot or unequally or by cutting them by too rash a heat.

I believe that ingots heated electrically would have some advantage over ingots heated in the usual way because they would probably be heated more uniformly and for this reason would roll better on the mill and no doubt require less power in rolling. They would be free from cutting or washing, and would have less scale.

I think Mr. Bailey states in his paper that about two hours is a proper period of time for ingots to remain in the soaking pit. This may be true, but I think that few plants give as much time as this to ingots charged hot unless in the case of special steels. I have visited several plants, investigating their ingot heating practice, and have found scarcely any that have what they consider sufficient heating capacity. It is frequently the case that ingots are drawn and rolled within an hour, if charged hot, and this is generally necessary in order to keep the mills going bearing in mind that a great many heats have to be charged comparatively cold on account of the bunching of heats which unavoidably occurs in any Open Hearth plant.

The capacity of the pits is thus overtaxed, which wouldn't be the case if they were served with steel from a Bessemer plant where heats are delivered at regular intervals.

I think that the charging temperature of about 1850 deg. F., which Mr. Bailey states as possible to average, is far too high to expect to attain regularly. While we may charge some heats that hot, I think that the general average is much cooler than that.

There are probably few appliances or installations around a mill less efficient, or which causes more trouble in the way of up-keep, than the soaking pits. They have to stand a great deal of abuse. The dropping of a 7,000 pound, or heavier, ingot on a cover; the abuse to which the walls and tops are subjected when the craneman draws an ingot with possibly a good sized fin on the bottom and tries to take it to the mill before it is clear out of the pit, require rugged construction, much more rugged than Mr. Bailey has apparently shown in his design; but we must appreciate the fact that this design is only preliminary and that it seems to lend itself easily to great improvement in this respect.

There is one question which occurs to me which Mr. Bailey might answer later, if he has considered it, and that is, what is the limit in the size of the pits or in the number of ingots each pit should hold? Would the most efficient electrically heated pit be designed for four ingots, six, eight or more?

T. F. Bailey:* In regard to power factor this type of furnace would show a power factor always above 95%, and in most cases 97 to 98%, due inherently to the type of furnace, as it nearly approaches to the carbon type incandescent lamp.

As to the heating of ingots at Donner Steel Company, I think 2350 deg. is perhaps a higher temperature than the average steel taken out of gas pits, but with the installation of the electric pit where the temperature could be maintained at the best rolling temperature the men on the rolling mill said it gave them better ingots than they ever had before.

As to repair cost, I mentioned in this paper no repairs to the brickwork whatever or walls. However, there have been three furnace troughs put in, one carborundum, one crome, the other magnesite. Due to the fact that hot carbon in contact with hot chromium oxide or magnesite will reduce immediately to their metallic state, both the latter troughs failed.

As to cost: The average cost in most mills furnished power from waste gas, the usual figure is .006. You have heard Mr. Horgan of the Ohio Public Service Company saying: For this class of load under favorable conditions you would earn a rate of .007; so the rate at Buffalo is not much better than you could earn in your own districts, either with your own waste power, or from power purchased from central stations.

As to efficiency of gas fired pits: Some one mentioned 1600 cu. ft. of gas at 15c; that is a fuel cost of 24c. We will take a figure of .007 on power purchased from central stations and 60 K.W. per ton. If you charge ingots at 1670 deg. skin temperature, (and heat 2250 deg. and most don't go above 2250 deg.,) but taking that figure, we have a cost of 24c for fuel, and if we deduct 2¾% for scale, which seems to be a fair figure, and steel at $30, which is about as low as steel rolled anywhere, we then have an actual loss of about 82½c in metal value, which added to 24c fuel amounts to $1.06½; compared with 60 K.W. hours at .007, which is .42, and ¾% of a metal loss at $30 per ton is $ .22½; so you have a cost of .64½ for Electric Heating compared with $1.06½ fuel fired, without taking into consideration the matter of repairs. As to upkeep and repairs: In a 4-hole pit, we will maintain a pit for 10c per ton. This is based on experience with over 160 furnaces of this carbon resistor type, 110 of which operated at about the same temperature as the soaking pit. Where we have a close line on the cost 10c a ton will be well within range.

The character of refractories; substantially all brick of a type known as Corundite. They are high in alumina and are not considered a very special brick. Under average conditions of electric heating, the same quality of brick will last longer in electric furnace than in fuel fired furnace, except perhaps in the matter of melting and refining furnaces where due to the action of high temperature of the arcs there is heavy cutting, but the refractory cost in electric furnace is probably not a great deal higher than in open hearth practice where you are dealing with the same quality of steel.

As to matter of cold ingots, I think this paper already mentioned under ordinary conditions you cannot afford to melt cold ingots with electric power, but when you take into consideration that most ingots are charged into pits hot and in most cases you can get them in hotter than you do now, the amount of heat actually required by the ingot is very small. In the Gjers type of soaking pit no fuel is used at all. One is at Birmingham. They have pits of the Gjers type, but have trouble with the top and bottom being colder than middle of the ingot

As to ingot capacity, as Prof. Trinks has mentioned, in all the mills I have been there are not enough pits, and the very contention he makes that there would be better heating and probably less scale loss if more

*Pres., Bailey Furnace Co., Alliance, Ohio.

pits were installed is reasonable because the pits have to be forced when mills are busy under present conditions. But even so the efficiency of the gas pit at the high temperature at which steel is gotten into the pit, is certain to give poor efficiency. Take for instance, the heat balance of a pit using 160 pounds of coal per ton for soaking ingots to 2250 deg. will be probably only 5 or 6 per cent. The same fuel used in making power would give you enough power to soak the steel in electric pits and give almost enough additional power to rolling steel as well. With an efficiency of 25,000 B. T. U.'s per K.W. hour, 111 pounds of coal would do the heating that now requires 160 pounds with fuel firing.

As to scabby ingots, from my observation of electric ingots, frankly, I do not think there is any advantage in Electric Heating as to surface conditions. If you are going to make scabby steel you had better keep gas heated pits. If you get ingots reasonably clean, electric heating will have a big advantage. It is necessary to soak ingots a reasonable time to get good rolling condition in either electric or gas pits.

As to chipping costs on alloy steel, we have no authentic records, but from observation, about 25% of the present chipping cost is due to bad soaking pit practice. Most of the steel rolled did not require chipping, being carbon steel.

As to the power required for rolling, if the steel is heated all the way through, it doesn't make any difference whether you heat it electrically or with gas, but the character of gas pits is such that you cannot ardinarily do such a good job as you can electrically. You have a pyrometer control on electric pits and you can't get the steel out of the pit until it is the right temperature. In the gas pit when the heater says it is hot enough, down to the mill it goes. If it rolls hard, it rolls hard, that is all there is to it.

As to design shown on the screen, I think you would find it a little more rugged than your gas pits. It hasn't any more vulnerable places, perhaps not as many. Your side walls have ports. You have got to take thrusts at the side. You have in this particular design a wall 27 inches thick and about 42 inches high; in other words, about 1½ that much in width and about 4 feet in height there, and you haven't any more than that on the port side of present pits.

If we were heating all of the steel in the ingot from 1670 to 2350 deg., we would have a power consumption a good deal higher than this 60 K.W., but the center of the ingot is far above the skin temperature.

H. L. Bodwell: Do they have to use coke in that pit for making slag?

T. F. Bailey: It is a convenient thing to put in as a cushion and it provides reducing atmosphere for the pit. I think the coke breeze required is about one-fifth as much as in ordinary fuel fired pit, which means a saving in pit cleaning; and none of the ingots come up with bottom material hanging on; they come up clean.

REVISED AND EXTENDED COPY OF TABLE No. 2—WHICH APPEARED IN MR. T. F. BAILEY'S ARTICLE

TABLE No. 2

Comparison of Electric and Gas Heating Cost, based on Electric Power at 6 mills per K.W. hr., Coal at $6.00 per ton gassified, Coke Oven Gas at 12½c per 1000 cubic feet. Metal losses at ¾%, 1¾% and 2¾%, and Steel valued at $30.00 and $40.00 per ton.

ELECTRIC HEATING Ingots charged at 1670° heated to 2350°		PRODUCER GAS HEATING Ingots charged at 1670° heated to 2350° F. 250# coal per ton	
60 KW hr, at 6 mills	$0.36	250# coal at $6.00 ton	$0.75
¾% scale at $40 per ton	.30	2¾% scale at $40 per ton	1.10
Renewals and upkeep	.10	Renewals and upkeep	.10
Total per gross ton	$0.76	Total per gross ton	$1.95
ELECTRIC HEATING Ingots charged at 1670° heated to 2250°		**PRODUCER GAS HEATING** Ingots charged at 1670° heated to 2250° 167# coal per ton	
50 KW hr. at 6 mills	$0.30	167# coal at $6.00 ton	$0.50
3.4% scale at $30 ton	.225	1¾% scale at $30 ton	.525
Renewals and upkeep	.10	Renewals and upkeep	.10
Total per gross ton	$0.625	Total per gross ton	$1.125
ELECTRIC HEATING Ingots charged at 1850° heated to 2350°		**COKE OVEN GAS** Ingots charged at 1670° heated to 2250°	
45 KW hr. at 6 mills	$0.27	4,000 cubic feet at 12½c	$0.50
¾% scale at $30 ton	.225	1¾% scale at $30 ton	.525
Renewals and upkeep	.10	Renewals and upkeep	.10
Total per gross ton	$0.595	Total per gross ton	$1.125
60 KW. hr. at 8 mills	$0.48	167# coal at $6 ton	$0.50
¾% scale at $40 ton	.30	1¾% scale $40 ton	.70
Renewals and upkeep	.10	Renewals and upkeep	.10
Total per gross ton	$0.88	Total per gross ton	$1.30

TABLE No. 2. Continued

60 KW. hr. at 1c	$0.60	167# coal at $4.50 ton	$0.375
¾% scale $30 ton	.225	1¾% scale $30 ton	.525
Renewals and upkeep	.10	Renewals and upkeep	.10
Total per gross ton	$0.925	Total per gross ton	$1.00
60 KW. hr, at 1.125c	$0.675	1,300 cubic feet coke oven gas at 15½	$0.195
¾% scale at $60.00	.225	2¾% scale at $30 ton	.825
Renewals and upkeep	.10	Renewals and upkeep	.10
Total per gross ton	$1.00	Total per gross ton	$1.120
60 KW. hrs. at 1c	$0.60	250# coal at $6 ton	$0.75
¾% scale at $60.00	.45	2¾% scale at $60 ton	1.65
Renewals and upkeep	.10	Renewals and upkeep	.10
Total per gross ton	$1.15	Total per gross ton	$2.50
60 KW. hrs. at 3¼c	$1.95		
¾% scale at $60.00	.45		
Renewals and upkeep	.10		
Total per gross ton	$2.50		

*"Essentials of Design of Electric Industrial Furnaces and Their Application to Leveling Up Load Curves"**

By GEO. P. MILLS†

THE speaker was fortunate in attending the Pittsburgh Convention on the day given over to the report of the electric furnace committee of which Mr. Geo. Schaeffer of Reading is chairman.

The work of the electric furnace committee of this organization has always been forward looking and it was particularly gratifying this year to see the major portion of the time given to the consideration of the industrial heating phase of the electric furnace field. This is as it should be.

While Mr. Seede's report covered some very important new features in the melting field, such as The Soderberg Salf-Baking Electrode, the Opening Roof and Multiple types of furnaces, the oil fired preheater and the induction furnace—the chief development activity during the past two or three years has been in the industrial heating field. This is the field toward which Central Station men are looking when they see visions of a heating load equal to the motor load within five years' time.

As a consequent of the unusual activity in the development, much has been written about the advantages of electrically heated furnaces.

At the risk of what may seem to be excessive repetition, it may not be out of place to briefly summarize the advantages of the electrically heated industrial furnace that are attracting the attention of Manufacturers, Heat Treaters, Power Engineers, and Public Utilities.

FIRST: Improved quality of Product, generally results from the installation of an electrically heated furnace, due to automatically controlled temperature, and the uniform heat application possible, in the properly designed electric furnace.

It has been said that the best automatic control can only approach the temperatury regulation obtained by a skilled operator. Theoretically this is true. We can conceive of an operator so perfect that he can anticipate a change in furnace conditions, or change in quality of fuel, or the barometer, or wind direction, and so change the feed as to compensate for them, and obtain a straight line temperature chart, and his perfection may be carried a step farther on the matter of burner regulation, flue, port, and damper adjustment so that uniform heat application may be obtained. No doubt there are such men, but it is seldom, indeed, that they are found operating production furnaces.

A reference to one of the electric furnace committee reports (Mr. Cones') will show that a large number of the installations described were put in due to trouble with quality of work produced by the equipment which was superseded.

Please do not construe these remarks to mean that the electrically heated furnace is a "cure-all." Nothing is further from the fact.

To be successful the electric furnace must be intelligently applied. There are problems that have not been solved, but we are working on them.

SECOND: Another important advantage is improved working conditions surrounding the operation of the electric furnace. This is attested by the fact that in plants where both electric and fuel fired fur-

*Presented at Philadelphia December 6, 1924.

†Engineer, General Furnace Company, Philadelphia, Pa.

naces are operated, operators consider the transfer to the electric a promotion. Go into one of these shops when the furnaces are being started and see the reasons. The fuel fired furnaces are emitting volumes of smoke and gas, and the electrics are clean, silent—but performing, nevertheless.

THIRD: Lower overall cost of production. Unless we can produce a more valuable product, or a given product at a lower overall unit cost of manufacture, the electric furnace cannot be justified, notwithstanding some of the intangible advantages which are difficult to capitalize at so many dollars and cents.

It is under this heading—"THE OVERALL COST OF PRODUCTION"—that it may be of interest to discuss the subject of this paper.

The factors entering into cost of production are:

1—Labor.
2—Accessory Equipment, such as Annealing Boxes.
3—Fuel or Energy Cost.
4—Spoiled work chargeable to Furnace Treatment.
5—Overhead, Repairs and Maintenance.
6—Floor Space Occupied.

In some classes of heat treament, labor is the largest single factor in the overall cost of the treatment. This is frequently found to be the condition, in making a study of fuel fired furnace costs. In the case of box annealing, the labor of loading and unloading the charge is a large item. In laying out an electric furnace, the labor item always receives serious consideration. Three cases serve to illustrated this point:

A large annealing furnace, having a total installation cost of approximately $25,000 will operate with a labor saving alone that will pay for the installation in less than a year.

A manufacturer producing large quantities of enamelware has cut the overall unit cost of manufacture in something less than half by the installation of an electric furnace which eliminated 27 men who were required by the superseded method of production.

A 105 KW Continuous furnace for vitreous enameling, is being charged by one girl, whereas two skilled men would have been necessary for the operation of a batch type fuel fired equipment.

A large part of the saving mentioned in these cases was possible only with the electric furnace. A small part could possibly have been made by rearrangement of fuel fired furnaces. The entire amount, however, is credited to the electric furnace, because the improved methods were the result of thorough studies of the operations made by the plant engineers when considering the problem from the electric furnace standpoint.

Where equipment is in the hands of unskilled labor, as in the cases cited, inspection and supervision is necessary. The same sort of inspection and supervision that the balance of the electrical equipment gets in a properly organized plant.

The boxes in which work is charged in pack annealing and carburizing, are a never ending source of expense. On some classes of work, such as annealing of electric sheets in the elevator type electric furnace, we have been able to dispense with the boxes, the work being charged directly on the car which is elevated and sealed in the furnace chamber.

It is likely that within a very short time electric carburizing will be done without the use of boxes.

The elimination of boxes of course not only saves the cost of boxes, but reduces the handling charges and lowers the energy consumption by the amount required to heat the boxes.

(3) The fuel or energy cost is governed chiefly by two factors, namely, the power rate and the design of the furnace, with respect to the work to be done. We shall consider these items more fully in what follows.

(4) The value of work spoiled, due to defective furnace treatment, must, of course, be charged up to furnace operation, just as labor and fuel or energy cost. In some cases the total cost of treatment is a small part of the value of the product, so that a very small percentage of rejections can easily add a large per cent to, or even double or triple the treatment cost per unit of finished saleable product.

(5) Although the first cost of the electric furnace is usually considerably more than the fuel fired type, the total annual charges of overhead, repairs and maintenance will usually show a substantial saving in favor of the electric furnace. This is due to the well-known fact that, barring accident, the maintenance on the modern electric furnace is negligible.

(6) The space required by the electric furnace and panel is usually less than required by the fuel fired furnace and its fans, pumps and necessary storage facilities. Floor space has a definite annual value, dependent upon the location of the plant, the character of building construction, and kind of product that can readily be capitalized. Elevator type furnaces, used on sheet annealing require one-half to one-third or less of the floor space occupied by fuel fired furnaces for the same output. Further, this type of furnace allows the full use of trackage under the furnace for the movement of material on cars.

The above figures are based on actual furnace area alone and do not take into account fuel storage space required by the fuel fired furnaces.

Coming back to fuel or energy cost of the electric furnace, the leading question is: "How does the cost of operation of an electric furnace compare with oil or other fuel fired furnace?" Snap answers to this question are often misleading.

There are just as many answers as there are power rates, and local conditions surrounding the operation of the furnace.

In speaking of the cost of power we will use the central station terms of "demand charge" and "energy charge." These are basic factors in the cost of power, whether it is purchased from a Public Utility or generated by the user.

The usual power rate schedule is made up on the basis of a primary or demand charge plus a secondary or energy charge. The relation of these two charges varies with different plants, but the energy charge is usually scaled downward so that when a load factor of 30% to 40% is maintained, the energy charge per KWH is well below 1c. Some actual figures run from .5 to .8c per KWH. In a large steel mill operating on reclaimed gasses this figure may go as low as 3½ mills.

In making a study of operating conditions that will effect the lowest overall cost, attention must be given to the methods that will take advantage of the lowest power rates available.

From the standpoint of power cost alone, the rate will be highest when the furnace is operated during the day without respect to the peaks on the general motor load, so that the connected load of the furnace will show up on the demand charge. Even then, the rate of power for the electric furnace will not be as high as the general plant load, because the energy charge for the furnace will come in the lower, if not the lowest, energy charge bracket.

The method of operation that will earn the next lowest rate is continuous operation, where, although the furnace shows up in the demand a low average rate is earned due to the high load factor.

On certain classes of heat treating, such as annealing, normalizing, carburizing, also core baking, and in some cases other classes of heating, advantage may be taken of the off-peak periods and the furnace operated so as not to increase the demand. In such cases, the power rate on the furnace becomes the energy charge alone.

Where the production is small, the labor item may be the determining factor, so that it may not be possible to take full advantage of the lowest power rate. On tonnage production, however, this will not be the case, on account of the relatively small amount of labor required to handle tonnage work through the electric furnace.

In this connection, the use of the power governor or maximum demand regulator developed and perfected by Mr. Edward T. Moore, of Syracuse, one of your members, makes it possible to float the furnace or furnaces on the line without exceeding a predetrmined demand, thus insuring the use of off-peak power, available at the energy charge alone. This regulator is applicable to both the integrating and curve drawing methods of registering demand, and is provided with an adjustable time element feature, the setting of which is dependent upon the ratio of the controlled furnace to the total plant load. The regulator can be used effectively where the demand period is as short as one minute, which is unusual, the usual periods being 15 minutes or 30 minutes. The

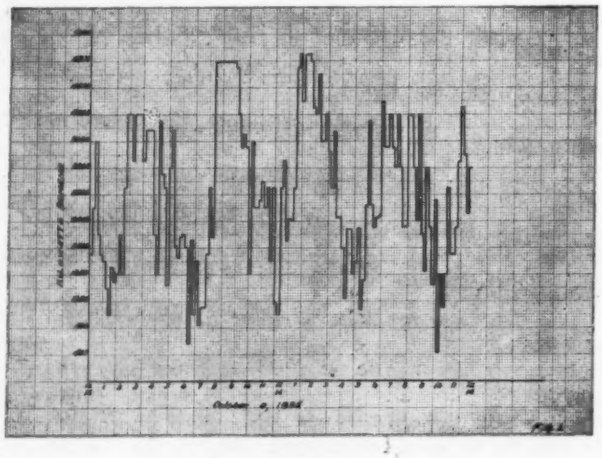

FIG. 1

regulator is energized by instrument transformers in the main power line on which it is desired to limit the demand and functions through relays to reduce the load or open the circuit on the furnace being controlled, when the demand approaches the predetermined limit.

Even in plants operating at a fairly high load factor, it is surprising to note the amount of off-peak KWH's available. Three slides have been prepared to illustrate this point. The curves on the first two slides were extracted from the demand chart of a steel mill having a demand of approximately 5000 KW for the month of October, 1924. The chart speed was about 3 inches per minute, so that a fairly accurate indication is shown.

Fig. 1 shows the demand for the 24 hours of October 9th, the day on which the maximum demand was registered. The average demand for each 10-minute interval is reproduced on the slide. Out of the 24 hours the peak demand was used 2 hours and 10 minutes, leaving available 800 KW for 21 hours and 50 minutes, or nearly 17,500 KWH at the energy rate alone.

Fig. 2 shows the demand for October 5 to 11, the week during which the maximum was registered, and

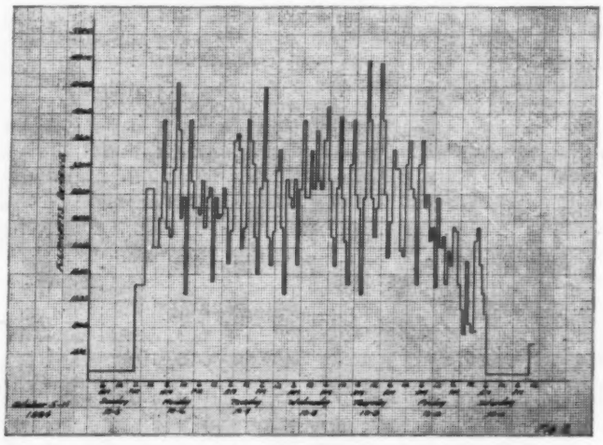

FIG. 2

after an inspection was made of the entire month, was taken as typical. The average demand for each one-hour interval was extracted from the demand chart and reproduced. It will be noted that 800 KW is available for 164 out of the 168 hours of the week. Taking the entire month, 800 KW was available for 724 hours out of the 744 hours in October.

On the basis of the week there was a total of 164x 800=131,200 KWH available at the energy charge. On the basis of 80 per cent load factor, 105,000 KWH could be used in electric annealing furnaces. At 10 lbs. per KWH, this is equivalent to 525 tons of steel annealed.

Looking still further into this Fig. we find that there are 1200 KW available for 155 hours, and 1600 KW available for 144 hours at the energy charge.

Fig. 3 is the approximate composite 24-hour load curve of a large gear manufacturing plant. The broken line shows the application of an annealing furnace, elevator car type, of approximately 340 KW which is now being installed. The heating elements in this furnace are divided into six equal sections, so that full advantage may be taken of off-peak power during afternoon and also during the morning, when the demand will be kept practically constant. A "Moore" demand regulator is being applied to this installation. Over 5700 KWH of off-peak, low cost power is available for use in this furnace, and as will be noted,

there is still a large amount of off peak power available for additional furnace equipment. These illustrations indicate the possibilities of off-peak power in connection with industrial electric furnaces.

On long annealing cycles the timing of the charges can usually be scheduled so that no extra shift men are required—time switches being used to cut power on or off at predetermined times.

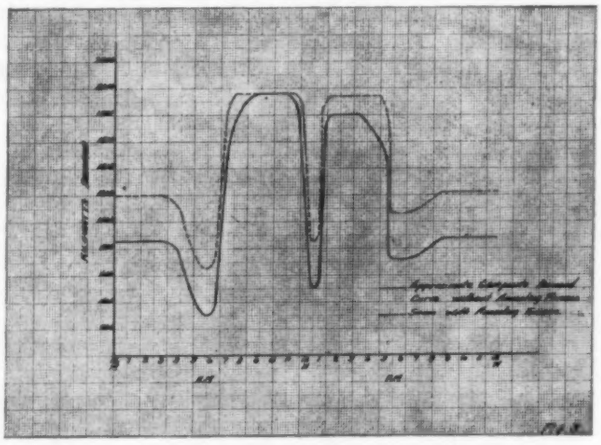

FIG. 3

By the use of a program timing device, it is entirely practical to actually shift charges, by the automatic operation of doors and pushers.

An interesting proposition under consideration now is that of annealing malleable iron with off-peak power. The furnace with a cold charge will be thrown on at 5 o'clock and will be up to temperature by 6 the next morning. Thereafter, the power input will be reduced to take care of radiation losses and the furnace will float on the line during the day, through the functioning of a power governor.

Furnace Design

All the foregoing are considerations outside the furnace. Naturally the furnace itself must be right.

The application of heat to the charge is all important, not only from the standpoint of uniform heating,

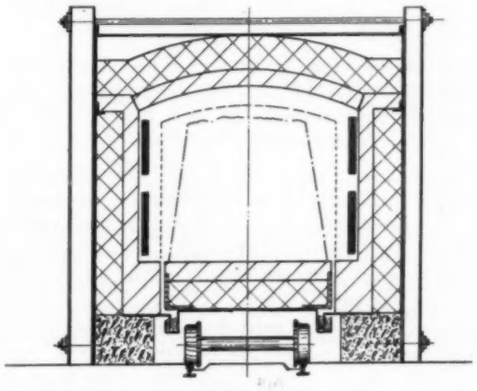

Fig. 4

but because it effects the time of heating and therefore radiation losses.

Fig. 4 shows an improper method of loading, which has been widely used in annealing steel castings in fuel fired furnaces and is still being used in many places. It is impossible to get uniform heating, and it takes an excessive time to get the bottom of the charge up to an annealing temperature. This is particularly true of the electric furnace. In the oil-fired furnace, the top castings are frequently burned by forcing the temperature at the top in order to get an annealing temperature at the bottom.

The correct method of loading for side wall heat application is seen in Fig. 5. The charge is raised

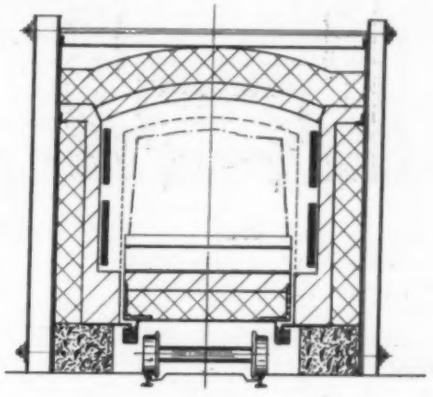

Fig. 5

above the furnace hearth so that the same heat conditions exist on all sides of the charge. Top, bottom and sides of the charge are exposed to direct radiation from the heating elements. The center of gravity of the charge is somewhat above the center of heat generation.

In a narrow car-type furnace the placing of heating elements on the car bottom depends upon the number of cars to be equipped, and therefore, the first cost, balanced against the saving in time to come to a uniform temperature, and therefore radiation losses. On cars wider than 5 feet it is generally necessary to

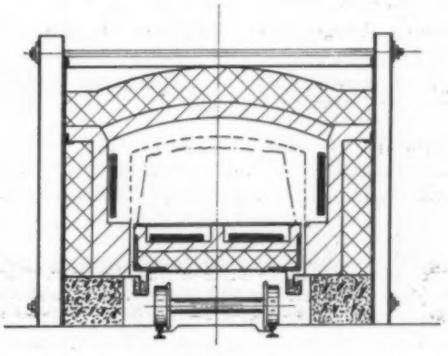

Fig. 6

have bottom heat for uniform heat application, irrespective of first cost. Even with bottom heat the method of loading is important.

Fig. 6 shows a bottom-heated furnace improperly loaded. There is a tendency for hot spots to develop and the charge is not uniformly heated.

Fig. 7 indicates the proper method of loading. The charge is slightly raised from the hearth and all heating elements are approximately the same distance from the charge. This type of furnace, loaded as indicated, will come up to temperature throughout in the least possible time and therefore will have the lowest radi-

ation loss per unit of product, of the four types just shown.

Where the character and quantity of the work permits, the use of a narrow, low, long furnace chamber

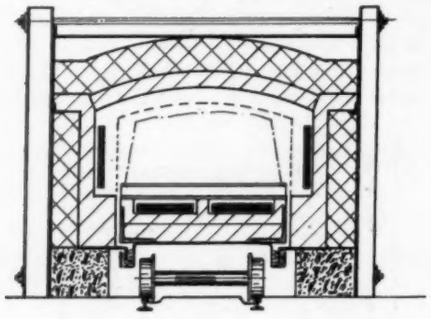

Fig. 7

of the continuous type is to be desired. This type is illustrated diagramatically in Fig. 8.

Every piece of work passes through identically the same temperature conditions. The heating element is shaded to indicate the volume of heat generated. The larger portion of the heat is generated on the charging end as the cold work has a greater capacity for absorbing heat than later, when it approaches the desired temperature. The heat is shaded down, therefore, to where radiation losses only are required. On the discharge end the element is shaded up again to compensate for the end and door losses, in addition to the normal side wall losses.

The losses on furnaces of this shape are exceptionally small, as the proportion of total area covered by doors is small. Although the design of furnace doors has been improved very much, indeed, the openings are sources of extra losses that have to be compensated for by generation of additional heat adjacent thereto. The theoretical calculations bearing on the amount of electric power required to heat a furnace and a given charge are complete in one formula, namely:

$$\frac{\text{Weight} + \text{specific heat} + \text{temperature} = \text{KWH}}{3412}$$

The amount of heat required for radiation and door losses, however, is determined by experience from innumerable tests covering many installations. The

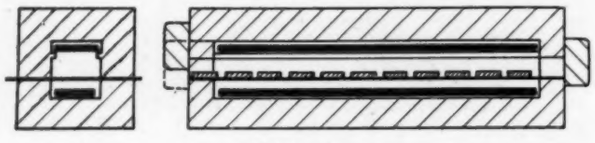

FIG. 8

items effecting these values are size, shape and type of furnace, the construction as to housing, insulation and refractory, and operation as to temperature and door openings. Figured in watts per square foot per hour, radiation and door losses, a 1550°F. range from about 320 on a small 12″x14″x6″ high laboratory furnace with 1″ refractory and 4″ of insulation to about 120 watts on a large specially sealed furnace with 4½″ refractory and 12″ insulation.

Assuming that we are going to have a properly designed furnace from the standpoint of heat application and insulation, the most important item affecting the overall efficiency, and therefore cost of power, is the capacity of the furnace in relation to the charge to be treated.

Where the purchase of a new furnace is considered, it is natural to take the best day's production we ever had, add a margin to it and say we want a furnace equipment to take care of the increased capacity. Unless this information is checked and corrected, the furnace, when installed, gets away to a bad start, because it will be under-loaded and the heating up and radiation losses are too large in relation to the power usefully consumed in heating up the charge. As with most equipment, the electric furnace operates at highest efficiency when fully loaded.

It is important that we pay particular attention to this item because we are dealing with heat energy having a relatively high B.T.U. cost, so that it is necessary for us to give careful consideration to the size and shape of furnace that will have the lowest losses for a given charge.

Due to flexibility of application of the heating elements, the electric furnace lends itself remarkably to meet a wide variety of charge conditions.

While we have a line of standard furnaces, we make a practice of fitting the furnace to the job,

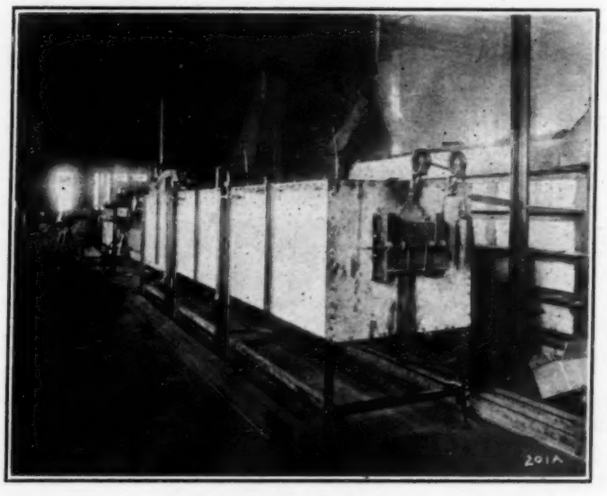

FIG. 9

rather than attempting to cut the job to fit the furnace. The majority of our installations are on large capacity production work and our designs are exceptionally rugged and well insulated.

The electrically heated industrial furnace has been progressing step by step toward heavy tonnage work. Starting in the laboratory it has become established in the fields of fine tool treating, automobile parts, vitreous enameling, annealing rough steel castings, forgings, and sheets.

Furnaces of large capacity have been installed where high-grade work is necessary, such as the heat treatment of gun forgings and the annealing of turbine castings. These furnaces have proven eminently successful from the standpoint of large capacity.

The general application of the electrically-heated furnaces to the tonnage annealing of strips, wire and sheets only awaits the reduction of overall cost of electric treatment to a basis more favorable to treatment in fuel furnaces. It is hoped that we have

covered some of the developments that are undoubtedly tending to bring this cost reduction about.

Fig. 9 shows another application of the ideal shaped continuous furnace. In this furnace the heating elements are placed above and below the hearth. The equipment is used for hardening and tempering steel bands and is applicable to strip annealing as well as heat treating. The hardening end is about 18′ long, the cross section of the chamber being about 12″x12″. The band passes through the quench tank shown in the center and then into the die tempering end, which is approximately 5′ long.

The Hydraulic Elevator Furnace shown in Fig. 10 is an excellent example of the progress made in the design and construction of the electric heating furnace. It consists of an inverted welded steel shell lined with insulation and refractory brick. All entrance bushings

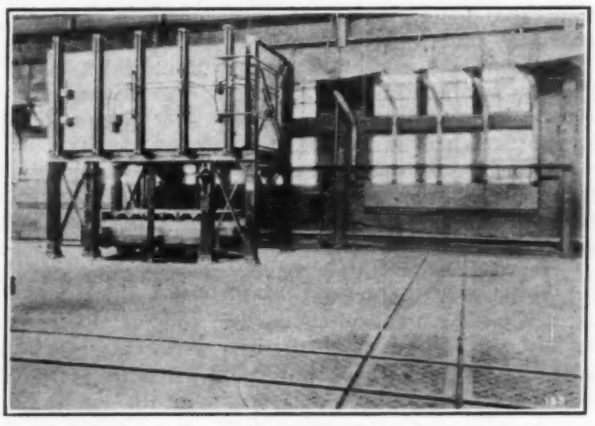

FIG. 10

are sealed and the lower edge of the chamber is fitted with a knife edge seal which registers in a sand seal channel around the perifery of the car.

The loaded car is raised into position in the furnace by an hydraulic elevator and locked into this sealed position by four safety locks, mounted on the structural supports of the furnace.

The furnace chamber is thus effectively sealed and a burned-out inert atmosphere is maintained.

Four of these furnaces are now being used on the annealing of silicon sheets. On this particular installation, the cost of annealing has been reduced by about four dollars per ton under the cost of annealing in oil fired furnaces. The furnace occupies about one-third of the space used by the superseded furnaces.

DISCUSSION

P. T. Vanderwaart:* I am sure we have all been very much interested in Mr. Mills' paper. He has treated the subject from a standpoint which should most interest us operating and application engineers. The heating elements, the control apparatus, the refractory materials, and the insulating materials are given us, and the success of the combination the success of which depends upon the skill of the designing and application engineer.

Mr. Mills has pointed out the principles which must be considered in the application of these materials, and he has indicated the methods of application. He has shown several examples of the successful working out of these problems.

I know that there are many here who have been up against these problems, and we look for a very active discussion of this subject tonight. It is a good chance for us to air our troubles and get straightened out on a lot of things we do not understand.

A. J. Standing:* The first thing I want to say to Mr. Mills is that the paper has been extremely instructive. To some of us, as in my particular plant, a large structural mill, detailed heating applications are not a serious problem as yet.

The re-heating furnaces are handled largely by coke oven gas and tar, but I can readily see from the drawings the vast application, the type of industrial application represented, would have, particularly in a smaller plant.

There is a factor which lies back of this electric heating which was not touched on, and that comes back to the ever present problem of the conservation of fuels. Looking over a Government record not so long ago, I noticed a statement to the effect that there are now about six hundred million tons of coal mined annually in the United States, and their very conservative estimate of that coal was that at least one hundred and fifty million tons, or a quarter of it, is wasted by inefficient application in the form of heating units.

That waste largely occurs in homes and in the smaller plants I should judge, due to the fact that in a great many large plants heating is under more efficient control than is likely to be the case in smaller plants.

Therefore, I say the application of this type of heating not only has its advantages from the cost standpoint in a small plant, but taking it from the over all conservation viewpoint, it would be primarily desirable in small plants if at all available from the cost standpoint of power, rather than putting in wasteful furnaces which consume gas, oil or coal.

The one outstanding feature particularly of value to all plants is the portability of electric fuel as compared to the cost of handling coal—the same thing is true of handling gas, and also in handling oil; the storage, the conveying, and the utilization of any of these fuels entail a considerable cost, expert service and maintenance; whereas in electric heating you have the extreme in portability of your fuel.

The other feature emphasized by Mr. Mills is the adequate control, which is not so easy to obtain with other fuels. Take in a case, as I said before, where we are using coke oven gas, which should be a certainty; but in reality is not. If you have a large unit the only uncertainty in connection with electricity is the chance of the power going off, which sometimes occurs.

There is one question, that is in connection with the latest development of furnaces involving the hydraulic car lift. Why is it in the modern development of the furnace the lift functions by means of hydraulics? Our tendency at Bethlehem, is to eliminate hydraulic wherever possible, because it is an expensive form of energy, and it lays itself open to so many losses, and I wondered why in the new type of furnace it should be applied.

One other question was a more definte parallel of costs. Take for instance, if you run in the neighbor-

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*Elec. Engr., Bethlehem Steel Co., Bethlehem, Pa.

hood of 600 B. T. U.'s, for high grade coke oven gas; your power would run you per kilowatt 3400 B. T. U.'s, and oil considerably higher. I was just wondering on what relative price of each of the fuels would be a common ground where you could decide in the case of a new installation, which would be the most economical one to install.

Geo. H. Schaeffer:* I have followed Mr. Mills' paper with much interest, and feel that he has given us valuable data on a subject rather new, but one that at the present time is assuming importance of the first magnitude.

I am particularly impressed by what Mr. Mills describes as the car type furnace and the claims which are made for it.

We are all familiar with the operations necessary in cold rolling high grade steels—namely annealing in iron pots and boxes. I doubt, however, if we all are familiar with the cost of these operations, that is, the cost of these iron pots (which are often alloy steel, to withstand the heat) and the labor required for packing, and the fuel for heating (note that the heating of the pot requires as much or more fuel than the heating of the steel because the pot weighs as much or more than its content.)

It is very interesting to speak of, and possibly accomplish all the savings mentioned, but it must not be at the cost of the quality of the finished product. We must not lose sight of the fundamental point, which embraces both quality and cost of the operation.

As to comparative costs of fuel and electricity, we should not figure the fuel consumption of an old, possibly half worn out furnace, and compare it with the best practice for an electrically operated unit. Personally, I would not like to install an electric equipment unless it showed a decided advantage over the best of any other type:

Mr. Mills' discussion of off-peak loads is very interesting. I believe that "off-peak" is subject to numerous interpretations and before one counts on "off-peak" load, it should be closely defined. To me it means use of power only during certain fixed periods. Most plants have continuous schedules so arranged that if the product of one department is not delivered continuously or on time—serious delay will result. If the delay can be avoided by using "off-peak" power, possibly an advantage will accrue, if delay cannot be avoided, it seems to me that no advantage will result.

The question of power demand or peak is not as important today as it was previous to 1918. The combining of the smaller plants into single systems and the gradual steps toward Super Power Systems, in my opinion, has resulted in better load factors—so that single customers will not cause the central station to invest same amount of capital per K.W. demand as previously. I would like to hear from central station men on that point.

C. F. Cone:† I enjoyed Mr. Mills' paper very much. Naturally this Association is composed of the large steel plants who are interested in furnaces on tonnage basis, and as yet the electric furnace has not obtained a foothold in that class of industry; but I don't think there is any question but what it is coming.

We are builders of large steel mill furnaces, both coal, oil and gas, and we are of the opinion that within three or four years there will be a large number of installations in steel mills, particularly for annealing.

Take the coal fired furnace, your fuel cost may be 60, 80 or 90 cents a ton, and your box cost will be anything from $1.50 to $2.00 a ton. The Electric Furnace will reduce the upkeep on boxes. The alloy people recognize this, as they will guarantee twice the life on an alloy box used in an electric furnace than they will in a combustion furnace; so by using the alloy box you will increase the life of the box, cut down the maintenance, but not only that, the box would be made lighter in section and you will decrease the heating time.

I think this is thoroughly shown in the installations made on carborizing furnaces. We have one case in particular where they do not use boxes; they use scrap steel punchings. They take 20 gauge steel, bend it into shape, put it through a heat, and throw it away. It so happens that this plant has a large amount of scrap steel, so it practically costs them nothing.

In regard to operating cost, I think that possibly the automotive industry has made bigger strides than anybody else. We had a report just before I left Pittsburgh, where we installed an electric furnace, and we cut their rejections from 16 per cent down to about 2 per cent on ring gears. They now permit their pinions to go through with the ring gears, on top of the ring gears, although the furnace was only designed for the ring gears, and they have cut rejections on the pinions from 30 per cent to a little less than one per cent. That is an enormous saving, and will easily pay for any excess cost of electricity.

R. L. Baker:* It is, indeed, gratifying to me to have heard Mr. Mills' presentation of the subject. I have heard lots of discussions and presentations of the subject of electric furnaces, etc., but none, I believe, were more comprehensive and clearly presented.

I might touch on a few things in connection with the Central Station end, as they are of interest to the buyer.

Mr. Mills referred to the off-peak feature in connection with the use of purchased power. I was very glad to hear his explanation as to usage of customers off-peak power. Generally speaking, the customer comes to us and wants us to deliver off-peak power without regard to their own off-peak privilege, which is nearly always present. In other words, if customer pays the demand charge, he is entitled to use the demand 730 hours a month, or thereabouts. Very few use their demand more than the equivalent of 220 hours during the month. I am talking now about the general run of large users. This question is important, the cost of power, as we see it, is going to be affected tremendously in the future by the heating load.

I do not know whether many of you realize that a large percentage of our costs are investment costs; and what a large percentage of the cost the number of hours usage of all the equipment we have provided to serve the customer is responsible for. I am not far wrong, in giving you rough figures, in saying that large power station manufacturing cost is about half a cent a kilowatt hour. Nevertheless, if we sold power at much less than one and one-quarter cents per kilowatt hour, even in large blocks, we might soon be ruined. A very large percentage of our costs, it can be seen, therefore, is represented by investment charges.

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†Engr. Rep., Geo. J. Hagan Co., Pittsburgh, Pa.

*Mgr., Ind. Power Service, Metropolitan Edison Co., Reading, Pa.

I am a great believer in the ratio that has been referred to from time to time—that our industrial load will be doubled in the course of five or ten years by the application of heat through uses of electric furnaces. This means doubling our load with practically the same investment except in such cases as where the peak—the present peak of the customer—will come simultaneous with the resultant peak load. Of course, we would not get the benefit expected if all the heating load were to be added to our present peak. There is, without a doubt, a large percentage of these industrial heat loads that can go on the customer's off-peak without adding expense to the customer by complicating his plan of operation.

Mr. Schaeffer very nicely covered this question in his discussion. I agree that there are some cases, especially with the larger customers, where it would cost more to control the use of power with the power governor for the particular period during which the plant peak is established than would be gained. In the case shown, the 800 kilowatts represented as available for heating off-peak could be used the other 20 hours in the month for about $800 at prevailing rates. It might be worth $800.00 in some plants not to try to keep off their own peak. So, as I see it, it is not a case of customer's off-peak possibility being a cure-all for every plant. Sometimes it would be found very desirable to use the full demand right straight through. However, it might prove a close guess to say 90 per cent of the heating business can probably go on what is now off-peak. Future reductions of the cost of central station power are going to come largely from some such application of the customer's utilization of demand, wherever possible.

I do not see where any great saving can be expected in the cost of generated power with the present type of generating equipment. We, the Central Stations, justify the building of a new plant where the engineers can make an expected saving of one or two tenths of a pound of fuel per kilowatt hour, but it is getting down to pretty fine problem, and the big saving in the future has got to come from the multiplicity of the uses of electricity with a resulting better system load factor. With this taking place there cannot be any mistake in considering that cost of electricity will be reduced to the customer. If we can sell twice as much power with our same investment, it would mean a saving of roughly half the difference of the cost of power between the station cost and the present total cost. I think that item of expense would be well worth saving, and naturally we are anxious to see power costs come down to the user as our costs decrease, because it means more universal use and general application of electricity in the field.

J. H. Miller:* I do not know that I have anything to say in reference to this paper. I was very much interested in what Mr. Mills has said. We took up this question of annealing furnace some years ago, but there was nothing done at that time on account of the cost, and also on account of the large size of furnace we would have to use for such work, and at other times the furnace would be unloaded, and we considered the thing was impracticable at that time. We are now using a six-ton Heroult Furnace for melting purposes and are worrying about the cost of power for this unit. We are working with the electric power company and they are working with us on the thing and trying to get some basis to bring that cost of power down. The cost of power is what is worrying us at the present time. I do not think we will do anything on the annealing furnace at the present time.

J. A. Seede:* The author has covered this subject in such a thorough and interesting way there is little left to discuss.

There are several points that struck me that might perhaps, bear emphasizing. In the first place, he said the electric furnace is not fool-proof and is not a panacea for all our ills. I think that is a point that is evident, because it is obvious mistakes can be made with an electric furnace like everything else, but if the furnace is installed properly and is operated with a reasonable degree of intelligence, then we have the electrical heat which will produce fewer mistakes with the same amount of care than any other heating medium.

Mr. Mills also referred to the preference shown by operators for electric furnace equipments. I happen to know of a case where electric furnaces are used for melting non-ferrous metals and when, for any reason, the induction furnaces are shut down and there is some special alloy to be melted in the fuel-fired furnaces, the melters usually take a vacation, especially in the summer-time.

The other point is the one brought up so many times about the cost of electric power. As Mr. Baker pointed out, we are all anxious to see the cost of power reduced, but it is never fair, without considering other items, to compare the cost of power on the basis of heat value against coal, oil, or gas, because when that is done, you are sure to get a wrong viewpoint. Usually the conclusion is reached that the electric power cost is excessive and you are scared off the proposition at the start. What really should be done is to take into consideration the factors that were brought up by Mr. Mills and Mr. Cone; that is, the cost of electric power should be understood in the terms of the product cost. As an example, suppose you compare an induction furnace melting yellow brass with some other furnace. The other furnace may easily waste 5% of the zinc content, that is, 100 pounds per short ton which, at 9c per pound, means a metal loss of $9 per ton. As the electric furnace wastes less than 1% zinc, that is, 20 pounds per ton, there is a saving of 80 pounds compared to the fuel-fired furnace or, at 9c per pound, a saving of $7.20. As the electric furnace melts the brass with 300 kilowatt hours, or less, to the ton and the power cost is 1½c per kilowatt-hour, the power cost per ton is $4.50. Subtracting $4.50 from $7.20 leaves $2.70, which is left to apply against other expense items after paying for the electric power required to melt the metal, from the saving in metal loss. Unless the cost of electric power is figured on some such basis, either on the basis of saving metal or increasing production by reducing rejections, as pointed out by Mr. Cone, it is impossible to obtain a true idea of the situation.

G. J. Walz:† Mr. Chairman and Gentlemen: Practically every one of the furnace men who spoke here tonight was free to predict that this electric furnace game would continue its present rapid growth until, sooner or later, it would reach a real tonnage basis. I have an actual case to tell about where this has al-

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*Elec. Engr., General Electric Co., Schenectady, N. Y.

†Asst. Elec. Supt., Bethlehem Steel Co., Bethlehem, Pa.

ready been done which was recalled to me by Mr. Mills' very interesting paper.

About eleven years ago there was a movement started at the Steelton plant, to produce a super-quality rail, one so much better than the ordinary rail, that it could be depended upon not to break unexpectedly and kill a lot of people, as ordinary rails have been known to do, and the investigations finally drifted around to the Electrical Department.

We made a lot of experiments with different round sections, from ¼" up to 4" diameter, and then with small rails, gradually working up to a standard size tee-rail, through which we had to pass 10,000 amperes, to heat it up to the proper drawing temperature, in a reasonable time, keeping the rail covered all the while with thermal insulation, to conserve the heat.

This electrical heat treatment produced a truly wonderful rail, as to strength, wearing qualities, toughness and especially uniformity, the result being, that we presently received a fair sized commercial order, which was filled in due time, although it was pretty slow work, as we only had rather crude, experimental equipment, to operate with.

This experimenting and developing took over a year, and just about the time we got the super-rail going pretty good, the war broke out, and we had to forget all about it, and the railroads were then mighty lucky to be able to buy even ordinary untreated rails.

But if we could get as far as we did on this proposition, at that time, there is no telling what the future may have in store for the electrical heat treating of steel on a large scale, especially as our cost of power has since then been so materially reduced by the installation of Bethlehem gas engines.

E. Green:* I cannot say very much concerning the subject under discussion. However, I was deeply interested in Mr. Mills' talk on Electrical Furnaces. At present our company is contemplating placing a furnace and annealing oven, but at this time I do not know what type or when it may be installed. This depends on rate or cost of electrical power. This lower rate must be obtained before we can definitely decide what to do.

Mr. Mills has furnished us with data relative to electric furnaces, also information concerning relays and maximum demands meters for holding a demand at a certain point, all of which we are considering.

F. O. Schnure:† There are just two questions I want to ask. One has to do with annealing furnaces and one with induction furnaces.

I was wondering whether there is any definite data on the cost of annealing sheets by electricity, full sized sheets, as produced by sheet mills for automobile work and so on. My understanding of the paper was that there was quite a saving—I understood the figure was $4 a ton. I would like to have a little discussion on that from the members of the Electric Furnace committee.

The question on the induction furnace is based on a report published in our plant that it was the general opinion at the National Foundrymen's Association at Milwaukee this fall, that the electric furnace was not successful in the reduction of non-ferrous metals. If that is so, I would like to have the Furnace committee tell us why.

R. M. Fuller:* I should like to ask Mr. Mills what the maximum temperature limits are in the ordinary car type furnace.

On a non-ferrous reduction proposition that I am personally acquainted with, the manager of the plant told me this fall that they have not yet been convinced they can use the reduction type of furnace for their particular product. They make phosphor bronze, nickel silver, and copper alloys of various kinds, and still use the crucible with the anthracite fire. So far the electric furnace men have not been able to convince them the electric furnace will stand the extremely high temperatures they require.

C. F. Cone: There is no doubt but what many of the faults in rejected automobile sheets comes from the source of the fuel in heating. I have seen sheets that have been rejected because of spots. These spots could not be removed by scrubbing. These spots were due to oil, soot, etc., in the furnace chamber. With a clean furnace chamber, like the electric furnace, these spots would be eliminated. I believe that the electric furnace can open anneal as good as most of the combustion furnaces anneal in boxes.

Mr. Mills spoke on the high silicon sheets. We have an installation where they use a heavy cast box to cover the sheets in an electric furnace. After the furnace was in operation for some time, they took some light punchings and placed them over the top of the stack with two heavy rails to hold them in place, and annealed in this manner. The sheets coming out of that furnace were better than they obtained in a combustion furnace with boxes. The boxes do not go along and fail all at once, they begin to leak, and the minute you get a leak you begin to spoil your sheets. They use the boxes as long as they can, and I know where poor sheets have been obtained in annealing and of sending a load of sheets to one automobile concern, have them refused, leave them on the same car and send them to another firm, etc., until they finally get them accepted. They know and they expect that defective boxes cause defective sheets, but they don't want to replace boxes too soon because that would boost their cost. I think, as I said before, that by reducing the weight of the box, lowering the upkeep that we can anneal automobile sheets in electric furnaces and do it at competitive cost, if we will consider the large rejections obtained now in combustion furnaces. On open annealing you ought to get anything from 235 to 260 kilowatts per ton; box annealing, probably 330 to 360 kilowatt hours per ton, due to the additional weight of the box.

Horace Drever:† Several questions have been asked tonight about sheet annealing and heavy annealing. I would like to give two or three examples of electric furnace annealing.

A 380 kilowatt furnace in this city is annealing very mild sheet steel rings, varying in section after cold rolling from 3-16 down to 3-32 inch. That steel is comparable to the ordinary sheet.

The comparison of cost was against that of oil at 4½ cents a gallon in the tank car at the siding or about 6 cents in the furnace, and electricity during the off-peak period of approximately 8 mills. The over-all cost was decidedly in favor of the electric furnace.

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†Supt. Elec. Dept., Bethlehem Steel Co., Sparrows Point, Md.

*Elec. Engr., U. G. I. Contracting Co., Philadelphia, Pa.

†Elec. Engr., General Furnace Co., Philadelphia, Pa.

The saving is possible partly on account of saving in fuel, but mostly on account of saving in annealing boxes which are entirely done away with in the electric furnace, on this particular operation, and also in labor.

Another case covers five furnaces in five different plants on sheet annealing.

In each instance oil costs between 6½ and 7 cents a gallon at the furnace, this cost including the power for compressing air and for pumping oil, and for upkeep of the auxiliary equipment. The cost of electricity runs from 1 cent to 1¼ cents per kilowatt hour. In each of those cases the electric furnace is annealing sheets without packing, and in each case the electric furnace has proved a sound investment and returns its cost within a period of a few years.

In another case, not involving sheets, but involving steel castings annealed in a compensating type of furnace, the average power consumption per ton of steel will be 240 kilowatt hours per ton. Oil is figured at 6½ cents and electricity at 8 mills. A decided saving in that case in favor of electricity.

Another case which becomes a little nearer to this, is in the use of electricity at 1¼ cents per kilowatt hour, used 24 hours a day, and the next cheaper fuel would be oil at 6½ cents a gallon. There the saving was due almost entirely to a 5 per cent decrease in the rejections that more than compensates for the increased fuel cost.

J. R. Penman:* I might ask Mr. Mills about taps and dies. I would like to know if he has any data on the use of any electric furnace on that particular case? If he wants any data on the size of the taps and weights, etc., Mr. Stafford, who is here, can give him the information.

George P. Mills: I am very appreciative, indeed, of the points that have been brought out in the discussion. I have noted the questions that have been asked, and I will go down the list and answer some of them.

Mr. Standing brought out two important reasons for using electrically heated furnaces, namely, the conservation of fuel, and the portability of the fuel. The manufacture of electric power from bi-product fuel, and then using that power efficiently in electric furnaces, is a similar proposition to the electrification of steam railroads—that is, fuel is converted into electric energy in large blocks, transmitted and converted into heat or mechanical energy at widely distributed points of use.

With reference to the hydraulic lift on the elevator furnace—we use electric power to drive the pump which supplies the energy to operate the elevator.

The elevator itself is used because of its very nice stopping characteristics, and the rigid construction that it is possible to get on the elevator. We have had those lifts operating for some three years now with practically no repairs. It might be borne in mind there that on an annealing cycle, the operation probably does not exceed twice a day.

In Mr. Schaeffer's discussion, he brings out the possibility of holding up production by operation on off-peak power. A study must be made of the conditions under which you are to operate, I grant that. There are certain classes of heat treating that you could not do on off-peak power, such as continuous hardening, because you must maintain your temperature constantly. But in many cases, on a fairly prolonged cycle of annealing, you can adjust your loading times so that the normal daily peaks will not interfere.

Answering Mr. Fuller's question, the highest temperature that we are now operating on a car type annealing furnace is 1850 deg. F. Under certain conditions we may go to temperatures 100 deg. to 150 deg. higher than this.

It is very fortunate that I have some of the Electric Furnace committee with me tonight to take up this question of non-ferrous melting, and I wish to thank the members of the committee for their discussions.

Going back to Mr. Standing's question on the definite parallel of costs between gas and electricity, Mr. Drever has given a number of figures which answer the question as well as I can, without going into details. That is the leading question I mentioned in the paper.

In answer to Mr. Penman's question on pipe threading dies, I have no doubt that an electric furnace could be made to pay for itself on dies. We have problems up now on threading dies which look very good, and with the experience that a number of people have had on treating punching and stamping dies, and considering the life gotten out of those dies when treated in an electric furnace, over the life in an oil fired furnace, I would say, that it is a proposition well worth looking into.

In closing, answering Mr. Stakes' question, about the power companies not penalizing the customer's high peak when it comes at their off-peak, that is being done in some cases now. With some central stations they have taken power contracts at a reduced rate, the provision being that the customer will be off the line during the power company's peak. That peak varies with different classes of load. In the case of the Commonwealth Edison Company the peak comes between 4:30 and 8:30 during the months of November, December, January and February.

In the case of a central station operating in the middle part of Pennsylvania, the majority of their load is industrial, and they have a fairly uniform demand from 6:00 in the morning until 6:00 at night. They have an off-peak contract giving special rates on power used at night only.

E. A. Hurme:* Mr. Chairman and Gentlemen: I was very much interested in Mr. Mills' paper, for one of the biggest things that we are up against at the present time is the lack of good application data.

The heat treating furnace industry today is in a similar position to the electric main roll drives some fifteen or twenty years ago, and you gentlemen know how little data we had and what a hard struggle it was to get it. Mr. Mills has given us some very good information.

I was much interested in Mr. Mills' description of using the off-peak power, for the scheme is not new. The same thing is being used daily in some steel mills, in connection with the main roll drives. There are steel mills where the electric motor load is, at times, beyond the capacity of the generating station. Also, in some A. C. motor drives, cases are known where

*Elec. Supt., Reading Iron Works, Reading, Pa.

*Manager, Steel Mill Section, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

they have found it necessary to limit the input to motor drive. To limit the power input naturally curtails the production, but the decrease in production is usually so small that it is well worth operating below normal production during those short breaks, when plant capacity is developed, rather than go to the investment of getting additional generating capacity. The same is also being done today in some cases where you buy central station power, but do not wish to contract for larger peak rates, because the peaks come only during two days a month like Mr. Mills showed in his power charts. There are cases where it may be better to go on this lower production during those two days than to contract for a larger load. Since the power input scheme is used in rolling steel, there are, no doubt, cases where it may be justified in industrial heating industry as well.

*Discussion: Gear Drives in Steel Mills**

By W. E. SYKES†

THE paper and discussion appearing in your December issue gives much valuable information which will doubtless be of service to your readers. But we find there are some erroneous statements appearing in the paper, and there are several interesting points raised in the discussion which were in some cases not fully dealt with and in other cases replies were given which, if not incorrect, were more or less misleading.

In the paper it is stated in reference to helical angle of teeth that an angle of 30° is to be preferred. With this statement we agree. It is further stated, however, that most of the European gears have a 45° angle. This is not correct. It is true that one European maker makes double helical gears with a 45° angle, but nearly all other makers cut with approximeately 23° or 30°. Probably not more than 10% of all the double helical gears made in Europe have 45° angle. At the present time approximately 50% of the gears manufactured have an angle of 30°, and this angle is being rapidly adopted. For steel mill work an angle of approximately 30° is desirable, and there are very few cases where any other angle is adopted except due to machining limitations of gear cutting machines.

The machines which we use for cutting our double helical continuous tooth gears will cut any helical angle up to 45°. We have, however, chosen an angle of 30° as standard, because we believe it is the best angle for all medium and heavy drives. There are some cases not connected with steel mill machinery where an angle of 40° or 45° can be advantageously used. One most conspicuous example is the timing gears for gasoline engines. These gears run at a high velocity and have to transmit relatively small torque and silence is very desirable. All our rolling mill drives have been made with teeth of 30° angle.

Mr. Talbot says that, according to his understanding, the first machines developed in this country for cutting double helical tooth gears were built and installed in 1912-1913. I think this is hardly correct as, according to my information, machines were in use in this country in 1910 and 1911.

Mr. W. H. Burr asked during the discussion for some information relative to the increase in strength which would be obtained if the teeth were made continuous instead of being designed with a clearance circle in the center of the gear. Mr. Klein, in reply to this point, stated that, in his belief, the strength would be increased very little and that the additional strength would not give a tooth with uniform strength, and further that, with a tooth stronger in the center than at the ends, the best design is not obtained. This is a line of reasoning which is often put forward by those who are commercially interested in the manufacture of double helical gears and it always happens that those who put forward these views are connected with some manufacturing concern which does not possess facilities for making continuous tooth double helical gears. Double helical gears having cast teeth have been made for over a century and they have all been made with continuous teeth having sharp apices. If there were any advantage in making a gap at the center of the teeth undoubtedly cast teeth would have been made with a gap. It is just as easy, however, to make cast teeth continuous as to make them divided, so that it has been the universal practice to make them continuous because, providing the manufacturing facilities exist, continuous teeth possess an advantage. Those manufacturers who have facilities for cutting continuous teeth advocate their use, because not only are the teeth stronger, but they have a greater load carrying capacity, due to the increased effective face width for a given overall face width. If all manufacturers of double helical machine cut gears could cut continuous teeth as easily as teeth having a gap at the center there would be no question as to which is the best. It is true that where the face width is very wide the percentage of strength gained by using continuous teeth is small, but where the face width is narrow in proportion to the pitch, the advantage to be gained by continuous teeth is considerable. Roughly, where a gear has a face width of five times the circular pitch the percentage increase of active tooth face is 20%. If, however, the face width is ten times the pitch the gain is only 10%. This is not a negligible amount and there are not a great many gears made with a face width more than 10 pitches wide. These percentages, however, only apply to continuous tooth gears having sharp apices, because those having curved apices do not carry a load on the curved apex. On the other hand, many steel mill gears are planed with a comparatively narrow gap at the center and there are several in operation where the load carrying capacity is not impaired more than 5%. The foregoing remarks on this point relate to tooth surface and do not take into consideration the question of resistance to breakage.

*Discussion in connection with paper appearing in December issue, Iron & Steel Engineer.

†Consulting Engr., Farrell Foundry & Machine Co., Buffalo, N. Y.

It is impossible to give any reliable figures because the amount of additional resistance to breakage cannot be either estimated or calculated in a general fashion. Concrete examples can be taken and even then many assumptions have to be made. However, if all prejudice is put aside, it is easy to see that a continuous tooth is, in the case of rolling mill pinions, a great advantage. Shrouding the ends is generally impracticable excepting when end-milling tools are used which, unfortunately, cause a loss of bearing surface at the center. Apart from the question of cutting continuous teeth with shrouds, there is the fact that it is impossible to shroud two mating gears up to the tips of the teeth. They can only be shrouded to approximately the pitch surface. It has been argued that there is an advantage in double helical unshrouded gears having a gap at the center. This argument is supported by the theory that such a tooth deflects uniformly under load. This reasoning is ingenuous, but it is unsound, because a helical gear does not take up the load uniformly across the length of the tooth. The contact lines take a path across the tooth surface at an angle to both the helical trace of the tooth and to the axes of the gears. Therefore, the load on any individual tooth commences in the case of the driver gear at the root of the tooth, at a point either at the center of the tooth face or at one edge. This contact point is gradually extended during the revolution of the gear diagonally across the face of the tooth forming the contact line referred to by Mr. Talbot, and ending at the top of the tooth. Therefore, the tooth cannot be under a uniform-bending stress and the argument of uniform deflection is absolutely unsound, but is unfortunately often readily accepted by those engineers who have not time or inclination to deeply study the subject. It can be shown that the continuous tooth double helical gear provides an increased resistance to breakage of from 5 to 50%, compared with a non-continuous tooth gear, depending on the tooth proportions. The complete proof of this statement, however, would entail many diagrams and much mathematical demonstration which we are unprepared at the moment to supply.

Mr. J. C. Reed raised the question of the use of helical gears on auxiliary drives and apparently did not receive from the other speakers much encouragement to use such gears. Machine cut double helical gears have been used and are used constantly in ever-increasing numbers for every type of auxiliary drive. They have not been used extensively in this country because a satisfactory herringbone gear could not be produced at a reasonable price. For the last two years we have been producing in this country herringbone gears which are as advantageous for auxiliary drives as herringbone gears are advantageous for main drives. We have been fitting them on armature spindles and using them for every kind of service and they have proved altogether superior to the ordinary spur gear. By the use of the Sykes gear generating machines we are now able to turn out gears of any size, small or large, for auxiliary drives at prices which make these gears more economical in every way than the ordinary straight tooth spur gear.

There is no more necessity to use an oil-tight gear case for double helical gears than there is for a straight spur gear A gear case is desirable for both types of gear or for any type of gear. Whatever the conditions of lubrication may be. a double helical gear will last longer, run more smoothly and do less harm to bearings and armatures than a straight tooth spur gear, providing the double helical gear is cut with continuous teeth having sharp apices on our gear generating machines and further provided that it is mounted reasonably correctly. There is no more difficulty in installing double helical gears than there is in installing any other type of gear except in very few cases, which, so far as we can ascertain, do not occur in any auxiliary steel mill drives.

Mr. Klein stated that single helical gears would work out to better advantage then double helical gears on small drives, due to the fact that they can be aligned up easier. This we do not agree with. Neither single helical gears, straight tooth gears, nor spur gears can work satisfactorily unless they are well aligned. Double helical gears can be aligned up just as easily as any other gears. Single helical gears, however, have the disadvantage that providing they are made with a helical angle, which is really of practical advantage, the end thrust is so excessive as to make them impossible of application. Single helical gears, with a very small helical angle, are to some extent used. The whole object of double helical gears is to permit a suitably large helical angle to be used. If single helical gears with a large helical angle could be used, there would be no reason to make double helical gears. If a small helical angle on single helical gears is all that is required, then there is no reason whatever to make a large angle on double helical gears. The fact that no large main mill drive is in operation with single helical gears should be sufficient to demonstrate to any engineer that the double helical gear possesses intrinsic merit, and a little consideration should also convince him that the single helical gear had only justifiable application so long as double helical cut gears could not be made. Historical events demonstrate this point very forcibly.

Dr. Hooke, in the seventeenth century, suggested helical gears and they were then made with cast or hand-machined teeth. Very quickly the double helical cast tooth gear was invented. When the cut gear became desirable no means were known for cutting double helical teeth. Therefore, the single helical gear again came into use. More recently means have been contrivd for cutting double helical teeth, which have again made the single helical gear antiquated, if not almost obsolete.

Mr. P. T. Vanderwaart stated that the construction with a slot down the center of the double helical gear makes for better oiling. This statement is difficult to account for. According to our most careful observations, one of the great advantages of double helical continuous teeth is the fortunate circumstance that they tend to better lubrication. If a pair of double helical continuous tooth gears are running at a velocity of say, 500′ per minute, and a quantity of thick oil is put on the teeth, the lubricant piles up towards the center of the teeth at the point of engagement and automatically covers the surface of the teeth without falling through the engaged teeth onto the floor. When there is a slot at the center of the teeth the lubricant falls through the slot and is of no use at all. All steel mill engineers are interested in reduction gearing, and it is our desire that they should be acquainted with recent developments. It is with this object in view that we have made the foregoing remarks. Developments in the art of gear manufacture

have been intense during the past five years. Many notable improvements have been made, some of which are somewhat slow in getting widely known.

Double helical gears are now cut without any limitations as to manufacturing facilities. Tooth profiles are now generated in all sizes of gears, whereas only a few years ago, gears over, say 1" pitch, could not be generated with accurate tooth profiles. The machines for generating continuous tooth double helical gears have only recently come into extensive use in this country. They were developed in Europe, and some of these machines were in use before the war. The war retarded development to some considerable extent, but since the war the development of this type of double helical gear has been very rapid, and has now reached probably as near perfection as any kind of practical mechanical contrivance can reach it. At the present moment there are between 60 and 70 machines in constant operation producing continuous tooth double helical generated gears of pitches from 1/32" up to 3¼". Although the machines are patented, their use is not a monopoly. We are not only prepared to sell gears produced on these machines, but we are also prepared to supply the machines.

ORGANIZING WELDING IN THE STEEL PLANT

(Continued From Page III.)

much time and putting the housing back into service with dimensions standard and good as new. It also often happens that the thermit weld follows an irregular course through the broken part, making the removal of the wax pattern slow and wasteful of pattern wax, and causing the mould to absorb wax which destroys the binding qualities of the facing sand. This

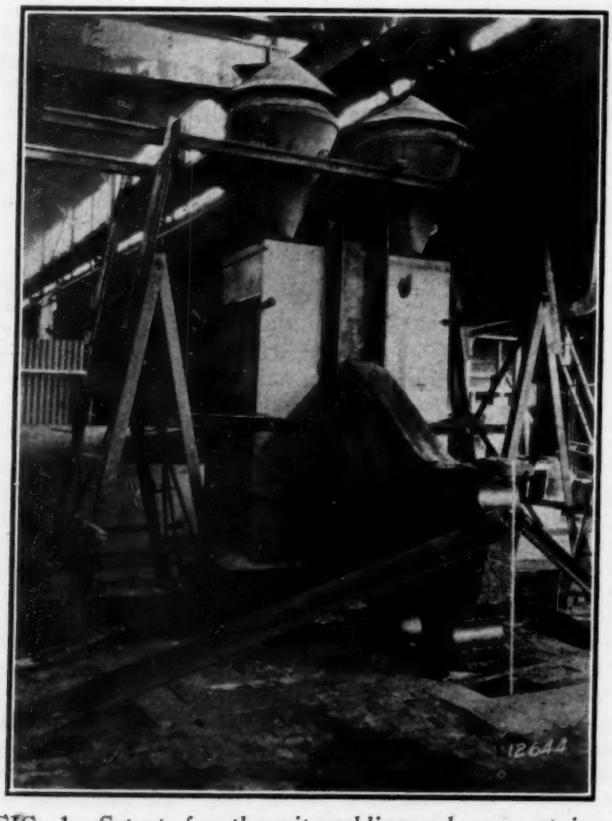


FIG. 1—*Set-up for thermit welding a large cast iron bar shear. The break in the casting started in the throat of the shear, which is approximately* 15"x15" *and extended through the rest of the housing, making a total length of the fracture* 63 *inches.*

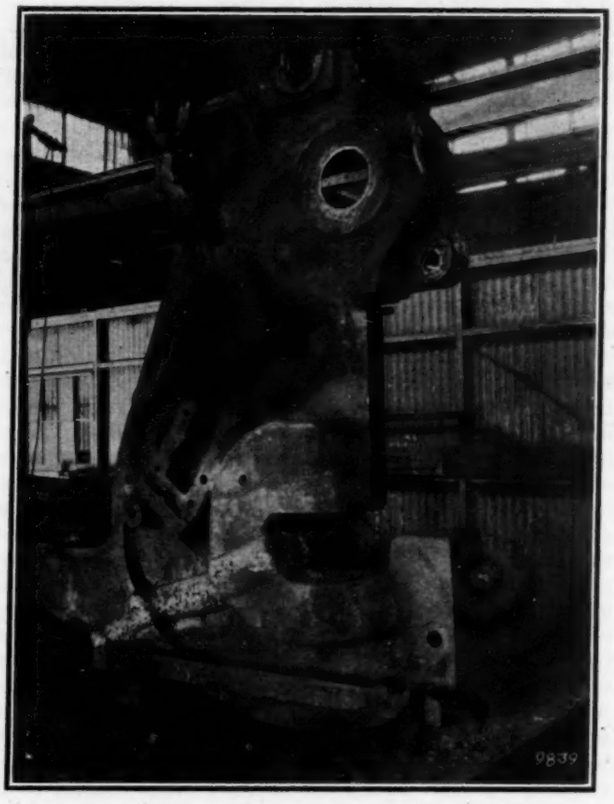


FIG. 2—*A view of the shear housing ready for service again. This was welded in January,* 1923, *and has been in service ever since.*

is easily alleviated by the following method, and illustrated in the sketch.

A wire is attached to the lower part of the fracture at the heating gate, and allowed to run to the top at the riser, care being taken to insulate it from the fractured surface by wooden or wax wedges. This is

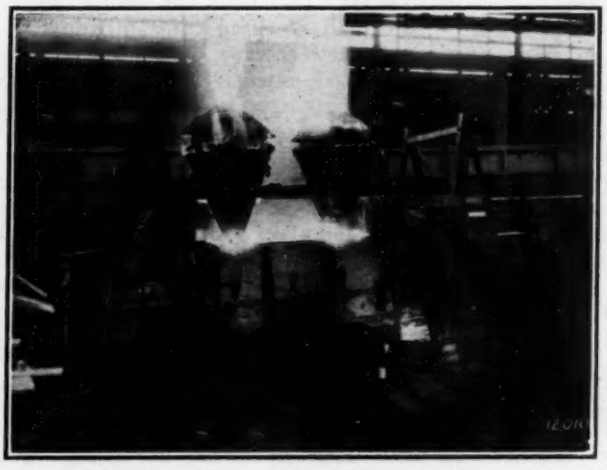


FIG. 3—*A thermit reaction using two No.* 10 *crucibles to weld a new end on a blooming mill pinion—*1,000 *lbs. of Thermit was used in this weld. This was* 22 *inches in diameter.*

done before the wax pattern is applied and it makes a complete electrical circuit through the wax pattern. When the mould is completed and the pattern ready to be removed, it is only necessary to attach an electric welding circuit to the end of the wire and on the

FIG. 4—*A sheet mill housing in service four years and still going good. A cross section through this housing measures approximately* 16″x28″.

broken part. By passing a small amount of current through the wire the latter is heated to a temperature that quickly melts the wax and opens a passage way through the center of the pattern. This does not burn the wax, nor does it allow it to soak into the sand mould, and in a few minutes the pattern is removed. Here again electric arc welding and thermit welding function properly together. Since in many mills these different methods are not perfectly understood by the

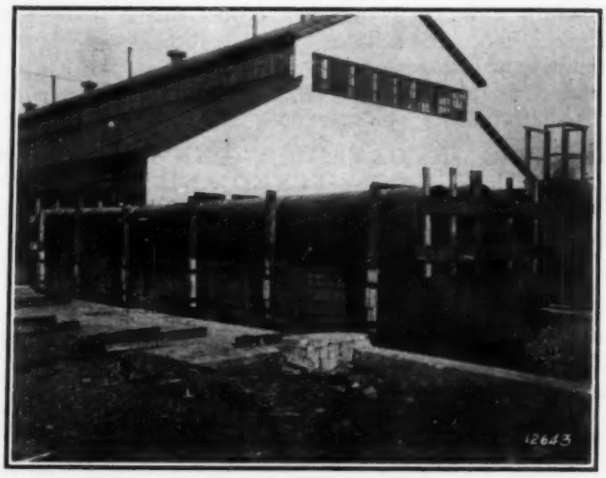


FIG. 5—*Part of a 36″ diameter water line being transported to the erection location. The pipe is formed of ¼″ ARMCO Iron plates and entirely electrically welded.*

men in charge, there are untold wastes of materials, delay in time, and damage done to the good name of autogenous welding.

We find in many steel mills today the old idea that electric welding must come under the organized electrical department and gas welding under the mechanical department, thermit welding being done mostly by blacksmithing departments. Now since the heads of these departments usually report direct to the operating management, they are each equally anxious to make a showing, and thereby do not succeed in doing all the work by the proper method or at the highest degree of efficiency.

Another very important point for consideration is the fact that the demand for gas, electric, and thermit welders varies from time to time as the work diminishes or increases in the respective fields, making it possible to draw on electric welders for the minor gas welding jobs and the gas welders for lesser electrical welding jobs and to give assistance to the thermit welders. In organizing a welding department to cover all the applications of autogenous welding it is therefore desirable that the head of the department report direct to the management, or, when an organized maintenance department has a department superintendent to which both the electrical and mechanical departments report, the welding department should also report to that superintendent. Where the company is large and has

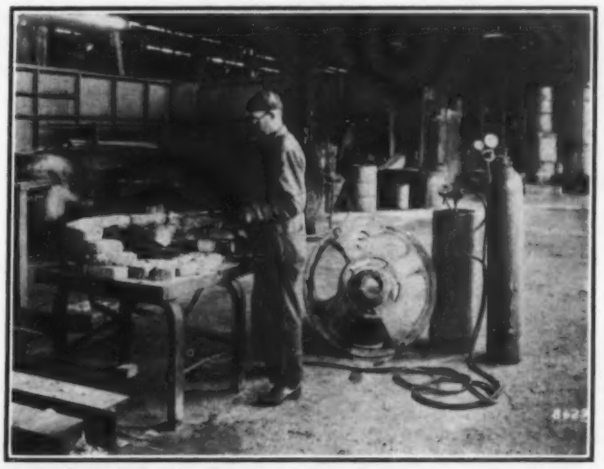


FIG. 6—*Miscellaneous cast iron jobs being welded by the Acetylene Gas process. The motor end bell had three spokes and oil guard broken.*

more than one plant, the welding supervisor should be in charge of all plants, making it possible to communicate new ideas and experiences direct between the welding organizations of each plant. In this way experimental or advanced work is not duplicated and slight advances can immediately be of benefit to all..

The organization outline then of the welding department would look similar to the following chart.

Production Management
or
Maintenance Superintendent

Supervisor of Welding

Research on Welding	Shop and Field Foreman	Classes or Welding School
Gas Welders	Electric Welders	Thermit Welders
Welder Helpers	Welder Helpers	Welders' He'pers

When welding is well organized and headed by one equipped to withstand the persistent efforts by salesmen of equipment and materials to make their equipment do all, or nearly all, these three branches of welding, a great increase in figures can be shown on the proper side of the balance sheet. First it is noticed in the reclamation or salvaging of broken equipment and later when carefully investigated will show a great

reduction in money invested in spare parts, with practically the same continuous operating assurance. The rapid strides in welding, starting shortly before and continuing through the world war, have been largely due to absolute necessity, while in the future new ideas derived from the manufacturer's needs will create the advanced research work on welding. It will be impossible for a manufacturer of welding equipment to get from his engineers the needs of the users of his equipment. Thus the future development of ideas or rather the organization of ideas must come from men who understand perfectly the requirements and who are well founded in the underlying principles of welding engineering. It is only reasonable, then, to assume that more importance will be attached to the position directly in touch with the welding operations if the most is to be finally gained from such a rapidly advancing branch of engineering. This will necessitate a closer relation of a research department to the operating department in the welding field.

The necessity for proper instruction of an up-to-date nature to be given the welders is very essential. For that reason, it is very important that any classes or

FIG. 7—*Bronze church bell welded to accommodate a local church. The weight of this bell was* 1,400 *lbs., height* 40 *inches, diameter at large end* 42". *The tapper weighed* 22 *lbs.*

schools be taught directly by the supervisor of welding, or at least scheduled and outlined by the latter. The importance of carefully educating welders to see through the essentials of metallurgy, chemistry and electricity cannot be stressed too greatly. Many have been disappointed in the results of their weld, who would have been pleased had they known some of the few chemical phenomena that take place.

A short condensed course for those not engaged in welding, but who have charge of the departments in which breakdowns occur, also helps very materially to put welding where it belongs. We often hear men that should know better make this break, "Cast iron can't be welded, can it?" Or, which is more common

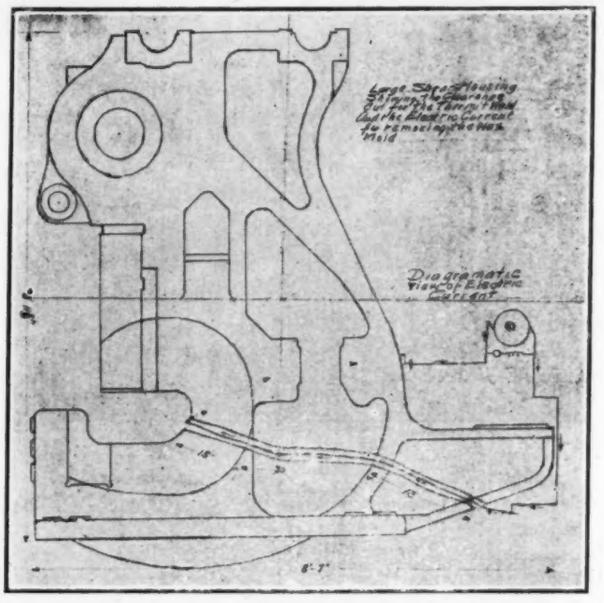


FIG. 8—*Sketch showing the clearance cut for the weld and the electric wire heater for removing the wax pattern.*

now days, "If we could only cut it with the acetylene torch, but it is cast iron." Now from master mechanic down to millwright helper and from chief electrician to motor inspector helper, every man should know that when a piece of machinery breaks, the quickest and cheapest way to replace it is to weld it.

FACTORS INVOLVED IN THE SELECTION OF DIRECT-CONNECTED AND GEARED MAIN ROLL DRIVES

(Continued From Page III.)

5. Methods of Connecting Main Roll Drives.
   Description with advantages and limitations of each method:
   a. Direct-drive.
   b. Chain drive.
   c. Rope drive.
   d. Gear drive.
6. Brief History and Development of Gear Drives.
   a. Lubrication.
   Requirements for proper lubrication especially in connection with gear units.
7. Importance of Accurate Alignment.
8. Couplings.
   Necessity for good flexible connecting link.
9. Application of Flywheels.
   Uses for and benefits derived from properly applied flywheels.

10. Position of Flywheel.
    Advantages and limitations of each of the following locations:
    a. In the rotor of the motor.
    b. On the motor shaft.
    c. On its own shaft and bearings operating at mill speed.
    d. On its own shaft and bearings operating at motor speed.
    e. On the gear pinion shaft.
11. Control.
    Proper utilization of flywheel effect requires adequate control. Different methods of control are described with advantages and disadvantages of each.
12. Cost of Installation and the Different Factors Involved.
13. Maintenance.
14. Standardization.
15. Plate Mill Drives.
16. Structural Mill Drives.
17. Sheet Mill Drives.
18. Merchant Mill Drives.

The last part of the paper goes more in detail concerning the initial cost, performance and space requirements of the four preceding mill drives. Recommended horsepower ratings and speeds are given, together with average flywheel effect requirements for each size and type of mill.

It may be of interest to mention that, for the first time, price and performance curves of various methods of drives for several representative types of mills will be published. This comparative data is so compiled as to make a ready reference which will enable steel mill executives and electrical engineers to more thoroughly analyze their problems and will assist in the selection of the type of drive best suited for the conditions.

NEW DEVELOPMENTS

Appleton Electric Co., Chicago, Ill.

The Mogul Type Reelite has been designed for use in connection with practically all types of portable machinery. This unit can be incorporated in new machines or attached to existing devices to definitely end the worries of portable cord maintenance.

The automatic reel holds and automatically retrieves cable of any number of conductors required and in varying lengths depending on the size of the cable.

The Mogul Type Reelite has eliminated the necessity of dragging long tangled lengths of heavy cable around over the floor when portable power machines are moved from place to place. All of the cable not needed is kept coiled in the steel container of the Reelite, protected, clean and unkinked. It is easily unreeled as the machine is moved to greater distances and automatically rereeled as the machine is brought closer to the power outlet, thereby saving considerable time.

Modern efficiency demands the use of Reelites wherever portable lights or motor driven tools or machinery are used. The extension cords can be kept out of the way, yet instantly available whenever needed, only by the use of Reelites.

Reelites keep cords neatly coiled in their steel containers, free from kinks, breaks or tangles. They pay out the cord as needed and then retrieve it when the job is finished. The action is entirely automatic—like that of a window shade.

There are many situations where bare current conducting rails are not practical from either a safety or operating standpoint. Loose cables dragged over floors through oils and under the wheels of trucks always require repair with a loss of operating time for the machine. The Mogul Type Reelite on any portable machines will eliminated a great deal of existing trouble.

"A"

Mogul Type Reelite as used in connection with lifting magnet on electrical traveling crane.

"B"

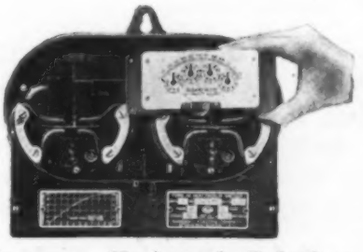
Mogul Type Reelite screw feed with 80 ft. No. 8-2 conductor cable complete with brackets for attaching to portable machinery.

"C"

Portable Type Reelite as used in connection with body inspection at the plant of Towson Body Company, Detroit, Mich.

SANGAMO ELECTRIC COMPANY, SPRINGFIELD, ILLINOIS

The Sangamo Electric Company has developed a maximum-demand attachment for use on its horizontal polyphase watthour meters. As this meter gives power-factor indications on balanced circuits, in addition to energy measurements, the use of a maximum demand attachment permits energy, kilowatt-demand and power-factor readings, to be taken on the same meter.



Sangamo Horizontal Polyphase Meter, showing power-factor graph; also maximum-demand register being applied.

This demand attachment, as well as the maximum-demand attachments for Sangamo single-phase and vertical polyphase watthour meters, can now be supplied with a contact device which will ring a bell, or give some other suitable signal, when the demand during any time interval reaches a certain pre-determined value.

Put a "Universal" there.

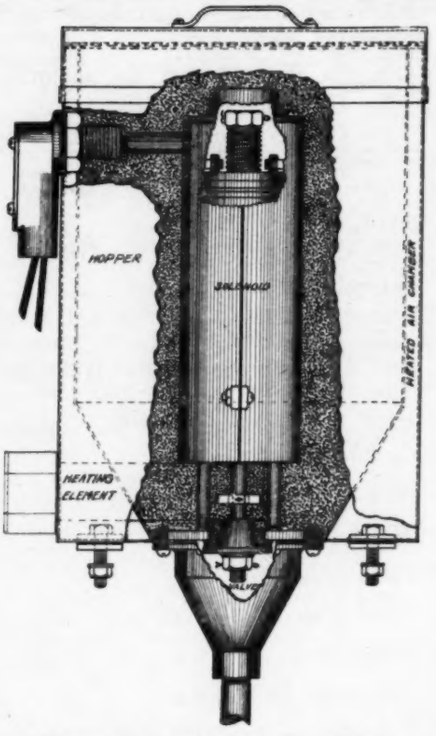
"Young Sol," shown above, is one of the N-L family of cast aluminum alloy "Universal" signal lanterns.

"Young Sol" is right at home in steel mill work. He sends a colored warning, **flashing, if desired,** hundreds of feet in every direction, and a brilliant, white light directly downward. Made in both one and two-lamp styles, according to purpose.

Where Safety Requires Light Put a "Universal" there.

Write for complete catalog of N-L cast aluminum alloy lanterns—a light weight lantern for every signal need.

N-L



Don't Stop the Crane to Sand Runways

Minutes are precious. The delay and danger in sanding rails by "hand and bucket" methods can well be costly.

And, while the operator clambers back to his cab, wind and rain often undo much of his good work, leaving the rail poorly sanded, with consequent poor traction to strain cranes and runways out of alignment. Unnecessary hazards, greater cost for operation and repairs.

Put Lintern Electro Magnetic Sanders on your cranes. With a simple pressure of the switch button, the operator drops sand on the rails directly in front of the wheels, **without stopping the crane or leaving the cab.**

Save men, save cranes, save runways, save time.

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N-L Products Manufactured and Sold in Canada by Railway & Power Engr. Corp., Ltd., 133 Eastern Ave., Toronto, Ont.